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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

APRIL 27.

Junior Institution of Engineers:—Ordinary meeting in London. "The Manufacture of Structural Steel, Etc." Paper by C. Hulbert Plant.

APRIL 28.

North of England Institute of Mining and Mechanical Engineers:—Joint meeting at Newcastle-on-Tyne. "Notes on Main Pumping." Paper by L. H. Forster.

MAY 3-4.

Iron and Steel Institute:—Annual meeting at the Institution of Civil Engineers.

The Institution of Mechanical Engineers:—General meeting in London. "The Causes of Failure of Wrought-Iron Chain and Cable." Paper by H. J. Gough, D.Sc., and A. J. Murphy, M.Sc., and the Third Report of the Wire Rope Research Committee.

MAY 8.

Institute of Metals:—Eighteenth annual May Lecture by Professor Cecil H. Desch, D.Sc., Ph.D., F.R.S., on "The Chemical Properties of Crystals."

MAY 12.

Society of Chemical Industry:—Joint meeting with the Birmingham Bio-chemical Society. Inspection of the new Bio-Chemical Department at the University, Edgbaston.

Institute of British Foundrymen.

APRIL 27.

London Junior Section:—Annual general meeting at 49, Wellington Street, London. Lecture on "Eyesight and Insight," by W. H. Poole.

APRIL 28.

Newcastle and District Branch:—Annual general meeting at Neville Hall. Discussion on "Foundry Problems," introduced by J. W. Frier.

MAY 5.

Lancashire Branch:—Ordinary meeting at Manchester. "Modern British Blast Furnace Practice," Paper by R. Sharpe.

The Grey Iron Position in America.

We are interested to learn that even in such a land of prosperity as the United States, iron-founders are faced with problems very similar to our own. A recent conference in Pittsburgh has taken the first step towards the formation of a "Grey Iron Institute," and a study of its proposed aims is highly instructive.

It proposes, roughly speaking, to investigate the whole range of buying and selling in the industry, together with the development of new methods, markets, and uses, improvement of the product, and possibilities of advertisement and publicity. Especially significant are references to the need for studying foundry costs and for encouraging engineering users of castings to buy in the open market, and to the whole question of restricting new entries to the industry and eliminating uneconomic units.

To a certain extent these problems are shared by founders in this country, and it is worth considering how far the Pittsburgh scheme is likely to offer a solution. Clearly the "Grey Iron Institute" cannot and will not do more than can be done by any strong and generally-supported manufacturers' association. Action by some such body, or by the various bodies that already exist for kindred purposes, must be a necessary preliminary to the solution of our own problems. Such solution may proceed along one of two lines, if it be the case that productive capacity exceeds requirements. The first alternative is to allow the smaller, less well-organised and weaker firms to be squeezed out by sheer economic pressure, a process that has been more or less in operation for the past five years; the second is for the makers to get together and recognise that such foundries not only endanger themselves but the whole of the rest of the trade, an additional danger being constituted by their temptation to produce indifferent material in the struggle to keep down costs. A poor casting hall-marks not merely a poor foundry but a poor industry. The Pittsburgh proposal for a "Grey Iron Institute" is, in fact, a proposal to change from the *laisser-faire* of the first to the constructive policy of the second method.

In the meantime there seems to be one likely way only for the small foundry to maintain its position and lay the foundations of future development—and that is specialisation. Specialisation may be on quality, in which case it would mean making a range of castings of particular quality and for particular types of service; or on quantity, in which case everything would be concentrated on producing a single line more cheaply than anyone else. Limitations would naturally arise; but this seems to be the wise policy provided that there is enough business in a given industrial area to warrant such specialisation. It is true that foundry costs are cut to the bone often enough, but too often they are based on the production of small quantities in shops equipped and manned for general jobbing.

Decisions of the nature suggested certainly require courage; but that is a quality which British industrialists have never lacked when faced with such emergencies as the present. J. G. P.

Nickel Cast Iron.

A subject about which a good deal has been talked and written during recent years, that of the use of alloying elements in the manufacture of cast iron, has been again brought into prominence by the Paper on "Nickel Cast Iron" recently read before the European Foundry Conference at Barcelona by Dr. A. B. Everest. It is a subject, too, about which there has been a good deal of misunderstanding.

When the idea of adding nickel to cast iron, for instance, first came to the forefront, the claims which were made caused some foundrymen to regard it as a cure for all ills—as a sort of pill which had only to be added to even the poorest material to rid that material of its inherent defects.

It was natural that such a misunderstanding of the function of nickel should give rise to much disappointment and, therefore, to antagonism. Practical trials of cast irons alloyed with nickel brought successful results in some instances, but in others just the reverse. Some foundrymen discovered that, under their particular conditions, the addition of nickel resulted in a cast iron whose properties were actually inferior to those of their former mixtures, and they promptly gave up the attempt at improvements in this manner.

Recent scientific research, however, both in America and this country has not only shown why these earlier experiments were unsuccessful, but has gone a long way towards showing exactly how nickel should be used to obtain beneficial results.

The knowledge gained from such work as that of Dr. Everest at Birmingham University indicates quite clearly that haphazard additions of nickel to any and all foundry mixtures can only by chance result in success, and that, even with satisfactory mixtures, the methods of manufacture play a very important part in the production of satisfactory material. On the other hand, it seems to be equally clearly demonstrated that with right mixtures and right methods, the use of nickel can, from all points of view, be fully justified.

The recent scientific discoveries of the fundamental effects which nickel has upon iron carbon silicon alloys in particular and cast irons in general have, so to speak, cleared the air to such an extent that foundries are now able to go

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forward with industrial development with adequate knowledge of what they may expect. This in turn has led to a pronounced and vital change of attitude towards alloying elements and towards nickel in particular, of which the fact that this was the subject of the only British paper read at Barcelona was such a marked indication.

Information on such alloying additions, which once was repelled, is now sought after with an eagerness that in many ways is unique in the history of the art of iron founding. Now that we realise the three essential points to be observed in making such additions, first, that nickel can only be added with success to properly balanced mixtures; second, that careful and scientific control is required in all the operations of manufacture, and third, that the particular mixtures to be used depend upon the desired properties and applications, the foundry industry will proceed to develop this material with full confidence in its ultimate success.

National Federation of Iron and Steel Manufacturers.

ANNUAL DINNER.

Sir Alfred Mond, proposing the toast of the "Iron and Steel Industry," at the annual dinner of the National Federation of Iron and Steel Manufacturers, in London last Thursday, said the one bright spot upon which he would congratulate the Federation was the relations existing between the employers and the employed in the industry.

Referring to the questions of railway rates, he said that if they continued to negative the advantage they had of being close to the seaboard in most of the heavy industries, and failing to recognise the influence of the railway rates, they would very seriously hamper if not destroy the industry.

Responding to the toast, Mr. B. Talbot, who presided, said that he was afraid the position of the heavy iron and steel industry was somewhat worse— so far as the general conditions governing its welfare were concerned—than it was last year.

"We are, in fact, both as an industry, and, indeed, as a nation, in the ridiculous position of being willing to subsidise foreign competition against our own workers.

"Imports of iron and steel, which could be produced in this country, are still being received at the rate of three-and-a-half million tons per annum. If only two-and-a-half million tons of these imports were produced in this country—and there is no technical reason why practically the whole should not be produced by British labour—employment would be found in the mines and in the works directly and indirectly involved for one hundred thousand men."

Mr. E. J. Fox, President-elect of the Federation, said "the pig-iron industry is liable to be dwarfed by its allied industry, steel, due to the fact that the steel maker produces pig-iron primarily for his own consumption and not for sale. He, therefore, appears before the world as primarily a steel maker, and not a pig-iron producer. Yet when it is borne in mind that pig-iron is the raw material of all forms of steel, wrought iron, and the foundry requirements of our engineering trades, its importance cannot be over-estimated. Further, if you exclude the pig-iron made from imported ores, and consider the larger volume made from our home ores, you find yourself handling five or six tons of additional materials for every one ton of pig-iron made. In other words, one ton of pig-iron represents the use and making of six to seven tons of British product, the cost of which—to the extent of 80 per cent. to 95 per cent. of the whole—being made up of wages. Further, the annual output of pig-iron is not materially less than the annual output of steel: and if to the one ton of pig-iron produced is added the five or six further tons of minerals which go to its production, you arrive at the importance of pig-iron manufacture from a national employment point of view.

"Thanks to natural resources and to their geographical position, an adequate supply of pig-iron might be available in this country for the requirements of the consuming industries. Yet our blast furnaces are to-day working not beyond some 60 to 70 per cent. of their capacity. In fact, our present output is actually less than it was some fifty years ago—to be exact, in 1880.

"The outputs of pig-iron for 1927 as a percentage of the outputs for 1913 read as follows:—

	Per cent.
Belgium	152
Saar	131
Germany	122
U.S.A.	112
Luxemburg	109
France	101
Great Britain	71
Russia	70
Canada	65
Poland	63

"Two requirements seem to be essential to restore prosperity to the languishing pig-iron producer at home; the first is to resuscitate the pig-iron consumer—the principal of which is the steel maker—by enabling him to trade in competition with his foreign rival; and the second is to obtain a reduction of railway charges in order further to reduce the present cost of British pig-iron, and enable the heavy industries to obtain a cheaper supply of their principal raw material to embody in their products, which have to face the competition of the world.

"In the Midlands, where pig-iron is made from local minerals, and delivered to consumers all within a radius of some 50 to 60 miles, over one-third of the cost of the pig-iron to the consumer is paid directly for railway carriage.

"With the costs of labour prevailing in the countries of our Continental competitors standing at about half—and even less—of that payable by us in this country, any question of competition is impossible, where the buyer is willing to accept the foreign-made product.

"We are always at our best when facing critical and difficult times, but the danger of the present situation is that the importance of the present critical position of our basic industries in relation to our permanent national well-being, does not seem to be sufficiently realised. It should, however, be borne in mind that as furnaces and works in our heavy industries go out of production it is doubtful whether they will be re-opened or replaced, and, consequently, such industries will gradually expire. We see this going on all around us to-day in the pig-iron producing world: and, unless steps are taken to resuscitate the consumption of pig-iron, there will be a further closing down of furnaces.

"The first essential is to secure that British expenditure is directed to the employment of British labour. Thus the needs of home industries should be supplied by other home industries, making a definite contribution of far-reaching importance to the solution of the unemployment problem.

"This is the most highly-industrialised country in the world. 28 per cent. of the population is employed directly in industry, apart from those engaged in agriculture. It therefore follows that prosperous industry should be the main concern of any Government, and that the whole of its policy should be informed and regulated to secure that end; as also to the securing of such economic conditions in this country as will ensure for industry fair play in competition with its competitors, and equality of opportunity on the assumption of equal technical efficiency."

Sir Philip Cunliffe-Lister (President of the Board of Trade) said they must not paint the picture too black.

"But while I know that the position is still very serious, I do not believe that this industry is down and out. I believe you will find ways in which the Government can help you. The more you help yourselves, however, the greater claim you have upon any Government to help you.

"I am sure that if the opportunity for common organisation is seen, it will lead to new common efforts and common research, and perhaps to common buying.

"I do not know whether that is right, but at any rate it might be worth studying. Given the signs there are at present, and this spirit in the basic industries of this country, I believe there is a steel lining to every cloud."

Random Shots.

Summer Time already! And let's hope that it will soon be summer as well! The fruit trees are in blossom, the B.B.C. are attempting once more to broadcast the nightingale, the railway companies are unearthing their bathing belle posters, and the I.B.F. has announced details of its Summer Convention. It only remains, therefore, for the sun to do his share, and then we shall all be merry and bright!

* * *

Following on my Chauncey Depew stories last week, there is another concerning a letter sent to that gentleman in his capacity as President of a certain railway company. "Dear Mr. President," the letter ran, "you are the finest after-dinner speaker in the world. I would give a great deal to hear the speech you would make after you had dined in the restaurant in your station in Utica." . . . The point is not likely to be lost on anyone who has ever been stranded on Crewe Station in the small hours, and has there sought much-needed sustenance. . . .

* * *

I have recently been reading sundry books on America, and can heartily recommend Philip Guedalla's impressions to anyone who is interested in the United States, and that to-day means practically all of us. It has the somewhat rare quality of appealing both to readers who have been to the States and to those who have that joy still ahead. Every returned visitor from the other side of the Atlantic will appreciate the dedication to the Pullman porters of America, and the loving references to them throughout the book, while stay-at-homes will enjoy the vivid descriptions and the various extracts from current literature. . . .

* * *

There is, for instance, the case of the police magistrate whose gratitude for a rise in salary overflowed in verse. Or the beautiful lady bandit about to be released from gaol who "has not announced her plans on regaining her freedom. . . ."

* * *

Cautionary Tales for Ironfounders.

Robert—who always knew best, and said so!

"Th' instructive tale I have for you
Concerns young Robert Pettigrew,
Who always thought that he knew best
And said so with the greatest zest;
In earliest infancy he tried
His mother's catering to guide;
At school he set his teachers right
Even when quite a little mite;
His parents dream of great careers,
Concerning Robert they'd no fears;
But Robert blithely upp'd and said:
'For ironfounding I was made!
Of all the trades that flourish here
It would best suit me, that is clear:
They need someone to tell them how,
And that I'd do, you must allow.'
Apprenticed in a foundry, he
Wasted no time, but spoke up free,
Telling his fellows what to do;
His mates and all the foremen, too,
They listened open-mouthed—then ran
To tell that most important man,
The foundry manager. Quick he came,
Inquired about young Robert's name . . . .
Advance came quickly after that:
Robert is now both sleek and fat.
The founding industry where he dwells,
Messages to the whole world spells,
Because it lent a willing ear
To Robert, who had ne'er a fear,
And spoke his mind.
And so you see
It's useful outspoken to be!"

Marksman

The Spanish Congress at Barcelona.

The first foundry conference ever to be held in Spain was opened on April 11 by General Barrera, who asked Señor Don Jose Serrat Bonastre, the president of the organising committee, to address the meeting. After emphasising the importance of the occasion, Señor Serrat said he hoped that the work started would result in the formation of a Spanish Foundry Technical Association. He pointed out that no country could neglect to take advantage of the results constantly being published by workers in applied chemistry physics. He felt that a meeting such as this was an indication of the interest taken in such matters by the foundrymen of the world. Finally, he expressed the indebtedness of the Spanish nation to all those who had travelled such long distances to participate in the Congress, and hoped that their stay in Spain would be both pleasurable and profitable. After repeating the speech in French, he asked Mr. V. C. Faulkner, a past president of both the Institute of British Foundrymen and the Foundry Equipment and Supplies Association, to reply on behalf of Great Britain.

Mr. Faulkner, speaking in French, thanked the president of the Committee for his kind speech of welcome, and regretted that the British delegation was so small. This he ascribed to the difficulties experienced in inducing the British business man to travel during the spring time, especially at a time when industrial conditions were assuming a more favourable aspect. Though there were more than a million unemployed in Great Britain, it should be realised that there were now more people than ever profitably engaged in trade than ever before in the whole industrial history of the kingdom. The industrial importance of Great Britain could be visualised by pointing out that the annual coal output of Spain was approximately equal to the British weekly production.

He regretted that both Mr. Goodwin, president of the Institute of British Foundrymen, and Mr. Winterton, the chairman of the Equipment and Supply Association, were unable to be present, but they had asked him to present their good wishes for the success of the Congress. Finally he hoped that as many as possible of those present would visit England in June, 1929, to participate in the third International Congress, to be held in London. It would probably be preceded by a tour of inspection, which would embrace all the principal industrial centres and beauty spots of Great Britain. Once again he thanked their hosts for the reception accorded to them.

Further replies were made by M. Ivan Lamoureux, representing Belgium; Mr. Vincent Delport, for the American Foundrymen's Association; Dr. Th. Geilenkirchen, for Germany; M. Magdelena, for France; Dr. Dresden, for Holland; Sig. Com. Ing. Vansetti, C.B.E., for Italy, and Prof. Pishek for Czecho-Slovakia.

Colonel Cesar Serrano, the president of the Permanent Commission for Testing Materials, who represented the Minister for Labour, said that too much importance could not be attached to the value of exchange papers, wherein each country's technique was disclosed for the general benefit of the industry. He announced that it was proposed to send a telegram expressing the loyal greetings of the Congress to the King of Spain and the Prime Minister.

The New: The Rail Park at the Works of Altos Hornos di Vizcaya, and—

The Exhibition.

The meeting then adjourned to the exhibition, held in the adjoining hall, where General Barrera formally opened the exhibition. Every lady present received a charming bouquet of flowers.

The exhibition was of considerable interest, as the major portion was devoted to exhibits by the foundries themselves. The art castings were of a very high order, but those of an engineering character were not quite of "exhibition" standard, from the British point of view. There were very few British exhibits, but that shown by the Spanish representatives of Messrs. Electric & Automatic Furnaces, Limited, was one of the most interesting in the show. The major portion of the equipment exhibits was German, though there was a fair sprinkling of American and French.

Works Visits.

The visits to works proved to be very interesting. The Hispana-Suiza concern possesses a factory comparable in every way with the best European practice. The output does not appear to be sufficiently large to warrant the latest labour saving devices in the foundry, such as continuous core drying stoves and the like. The machine shops, however, possess a fair range of the latest American machine tools.

The Terrestre y Maritima is a mixture of the old and new, and as usual the iron foundry falls into the former class. The steel foundry is being redesigned, and we were pleased to note that for its melting plant—a British 2-ton Greaves-Etchell electric furnace is nearly ready for putting into operation. The heavy machine tool shop has recently been re-equipped and is essentially modern.

The Technical School.

The citizens of Barcelona have every reason to be proud of their technical college. It houses about 5,000 students and is particularly well equipped in the metallurgical department. The mechanical testing laboratory is perhaps superior

The Old: The Ruins of the First Iron Works in Spain.

to those attached to any British University. This is explainable by the fact that it has to act for the State departments and the railway companies. It has a well-furnished metallographic laboratory, whilst the experimental foundry is splendidly equipped, possessing as it does cupola and crucible melting plants, drying stoves and an adequate supply of moulding plant.

The Technical Papers.

The papers submitted constituted a well-balanced programme. About half were presented on behalf of foreign associations. There were three from France, and one each from Great Britain, U.S.A., Germany, Italy, Holland, and Czecho-Slovakia. The British paper, being an original research by Dr. Everest and carried out at the University of Birmingham, was undoubtedly the best submitted, and the author was warmly congratulated on his painstaking work and the clear manner in which he presented the salient points whilst labouring under the difficulty of speaking in a foreign language. Dr. Moldenke's paper was of a general character, but carrying as it did the experience of a lifetime devoted to scientific foundry practice, the conclusions reached undoubtedly indicated in the clearest possible manner the directions in which future developments can be expected. In the discussion on several of the papers, the poor quality of the coke available in Spain for foundry operations was stressed.

A luncheon was offered by the Organising Committee to the leaders of the foreign delegations and the readers of the papers. This was held at the Ritz Hotel, and beyond a speech of welcome by Colonel Serrano, no toasts were offered.

An Interesting Steel Casting.

Whilst the majority of large propellers are made either in manganese bronze or cast iron, there are cases when steel castings are to be preferred. Our illustration shows such a case. It portrays one of four 4-bladed cast-steel propellers, made by Messrs. Wm. Beardmore & Company, Limited, at

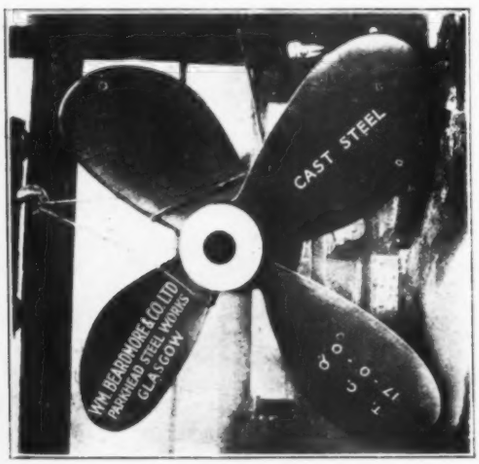


Fig. 1.—A Cast Steel Propeller, by Messrs. Wm. Beardmore & Company, Limited.

the Parkhead Foundry, for a boat of the Duchess of Atholl class, owned by the Canadian Pacific Steamships Company. Each casting weighs 17 tons and measures 18 ft. 9 in. between the tips of the blades.

Death of Commander Jackson.

We regret to announce the sudden death of Commander Jackson last Thursday. Commander Jackson was a director of Messrs. Robt. Hyde and Son, Limited, of Chesterfield and Sheffield. He was a Past-President of the Sheffield Branch of the Institute of British Foundrymen. As a councillor he did much for the City of Sheffield. On behalf of the foundry industry we offer to his family our sincere sympathy in the loss of one who was regarded with affectionate esteem by all with whom he came in contact.

American Foundrymen's Association.

PHILADELPHIA MEETING.

Special interest is attached to this meeting, to be held from May 14 to 18, as it will elect its president for the following year, and this office will carry with it the presidency of the International Foundrymen's Committee, and the honour of being chief guest at the Third International Convention, to be held in London in June, 1929. The gentleman selected is Mr. Samuel T. Johnson, of the S. Obermayer Company and the National Engineering Company, of Chicago, Illinois. He is a native of Scotland, who went to America in 1889. He was for some time connected with the Detroit Car Wheel Company, where Mr. J. H. Whitney was the superintendent. When Mr. Whitney organised the Detroit Foundry Equipment Company, Mr. Johnson was his chief salesman. Ten years later he joined the S. Obermayer Company, of which he is now vice-president. Recently he was also made vice-president of the National Engineering Company, of Chicago.

Mr. Fred Erb has been nominated vice-president. He is the president of the Erb-Joyce Foundry Company, of Detroit, and was for many years the foundry manager of the Packard Company.

An interesting event at this Convention is to be a reunion dinner of the members who participated in the first A.F.A. congress held in Philadelphia in 1896. We note with interest that amongst those present was Mr. Benjamin Talbot, the president of the Iron and Steel Institute.

The Exchange Papers are being presented by Mr. F. A. Melmoth, of Messrs. Thos. Firth & Sons, Limited, of Sheffield, for Great Britain, who is taking for his subject, "Variables in Steel Foundry Practice": by Mr. Dudouet, of the Foundry High School, Paris, on behalf of France, who is dealing with "Test Pieces for Ascertaining the Chill shown by Medium and High Silicon Cast Irons," and by A. Soupart, of the Morlanwetz Technical School, on behalf of Belgium, who is to contribute a study on "The Training of Foundry Executives and Labour." In addition, Mr. John Shaw, late of Sheffield, who is participating in the Convention, is presenting a Paper on "Theory or Practice in Grey Iron Foundry Progress?"

There is to be introduced what is termed a "Cupola Operation Study Course," and four sessions are to be held, when discussions will be opened by Dr. Moldenke, Mr. E. J. Lowry, Mr. David McLain, and Mr. H. W. Dieteit.

Reports are to be received from the Committees on Foundry Costs: Effects of Phosphorus and Sulphur in Steel; Heat Treatment of Ferrous Castings; Steel Castings; Sand Control and Malleable Iron.

The Other Papers.

Other Papers expected to be submitted are:—

"Furnace Refractories for Brass Foundries," by H. M. St. John (Detroit Lubricator Company, Detroit).

"Science in the Foundry," by E. F. Hess, of Ohio Injector Company, Wadsworth, Ohio.

"Risers: Their Need and Feeding," by R. R. Clarke, of the Alloy Foundry, General Electric Company, Erie, Pa.

"Casting Nickel-Copper Alloys," by Representative of Caskey's Brass and Bronze Works, Philadelphia, Pa.

"Economies in Oxy-Acetylene Cutting for Riser Removing," by G. O. Carter, Consulting Engineer, New York City.

"Sand Reclaiming in the Steel Foundry," by H. A. Mason, of the Gould Coupler Company, Depew, N.Y.

"Interdependence of Operating and Sales Departments in the Success of a Foundry," by K. V. Wheeler, of Lebanon Steel Foundry, Lebanon, Pa.

"Heat Treating Department of a Steel Foundry," by A. W. Lorenz, of the Bucyrus-Erie Company, So. Milwaukee, Wis.

"Theory of Cupola Operation in Relation to Practice," by R. B. Schaal, of Roberts and Mander Stove Company, Hatboro, Pa.

"Automatic Blast Gate Control for Cupolas," by H. W. Crawford, of General Electric Company, Schenectady, N.Y.

"Necessity for Creating a Castings Consciousness," by A. F. Jensen, of the Hanna Engineering Works, Chicago.

"The Schedule Fallacy," by J. J. Ewens, of the Geo. H. Smith, Steel Casting Company, Milwaukee, Wis.

"General Characteristics of Alloy Steel Castings," by J. Frank, of Chicago Steel Foundry Company, Chicago.

"Manganese Steel," by H. P. Evans and A. F. Burtt, of Pettibone-Mullikin Company, Chicago.

"A Modern Steel Foundry Research Laboratory," by W. C. Hamilton, of the American Steel Foundries, Indiana Harbour, Ind.

"Temperature Measurements of Molten Cast Iron," by H. T. Wensel and W. F. Roeser, of the Bureau of Standards, Washington, D.C.

"Influences of Carbon and Silicon in Cast Iron," by D. G. Anderson and G. R. Bessmer, of the Western Electric Company, Chicago.

"Some Recent Developments in Cupola Metal," by J. D. Miller, of Cresson-Morris Company, Philadelphia, Pa.

"Heat Losses from a 75-Ton Hot Metal Car," by W. F. Roeser, of the Bureau of Standards, Washington, D.C.

"Basic Principles of Management in the Foundry," by J. D. Towne, Consulting Engineer, Dayton, Ohio.

"Stabilising Labour and Cutting Costs," by A. D. Lynch, of the Ohio Brass Company, Mansfield, Ohio.

"What Does the Buyer Expect for His Money?" by J. A. Marks, Purchasing Manager, Packard Motor Car Company, Detroit, Mich.

"Surface Conditions of Castings as Affected by Core Sand Mixtures," by H. L. Campbell, of the University of Michigan, Ann Arbor, Mich.

"Testing Moulding Sands for Durability," by M. A. Blakey, of the International Harvester Company, Milwaukee, Wis.

"Sand Conservation and Control in a Grey Iron Jobbing Foundry," by T. F. Kiley, of the Brown and Sharpe Manufacturing Company, Providence, R.I.

"Sand Control Methods in a Light Casting Shop," by W. G. Reichert, of the Singer Manufacturing Company, Elizabethport, N.J.

"Materials Handling and Its Relationship to Building Plans," by E. F. Scott, of the Austin Company, Cleveland, Ohio.

"Reducing Scrap in the Malleable Foundry," by R. A. Greene, of the Ohio Brass Company Mansfield, Ohio.

"Need for Research in the Foundry," by E. E. Griest, of the Chicago Railway Equipment Company, Chicago, Ill.

"Malleable Foundry Problems," by R. J. Teetor, of the Cadillac Malleable Iron Company, Cadillac, Mich.

Book Review.

The Future of Tin, by Herbert Oakley and Evan Pritchard.—Published by the St. Catherine Press, Stamford Street, London, S.E. Price 6d.

In a covering letter, the publishers point out that this book is written by two well-known financial experts. This probably accounts for the mistake in the first headline, in which tin is described as the *super-alloy*. So far as our readers are concerned they can skip the letterpress, as it is written for non-technical readers, but they cannot afford to ignore the facts as disclosed by the series of excellent charts. For instance, we admit to a certain amount of surprise when we learnt that the foundry and allied industries consumes nearly 18 per cent. of the output of tinplate. The figure cited is labelled munitions of war; stove boards; furnace pipes and gas meters. This actually consumes more than the tinned-milk industry. It should be pointed out, however, that these figures relate to American consumption. To those of our readers who invest in tin shares, this carefully compiled booklet will be of as much interest as is the "form book" so closely studied by the horse-racing community.

Messrs. F. Eagles and J. Sharrocks, engineers and brass founders, East Philip Street, Salford, trading under the style of William Eagles, have dissolved partnership.

Chilled Iron Rolls.

By Archibald Allison.

(*Continued from page* 278.)

Microscopy.

In studying chilled iron rolls, the microscopic examination does not afford information commensurate with the labour involved in preparing pieces for examination. The structure of the chill portion is exactly what might be expected: pearlite and cementite in dendritic arrangement, with phosphide eutectic and manganese sulphide, according to the contents of phosphorus and sulphur present. When a roll is worn out and the

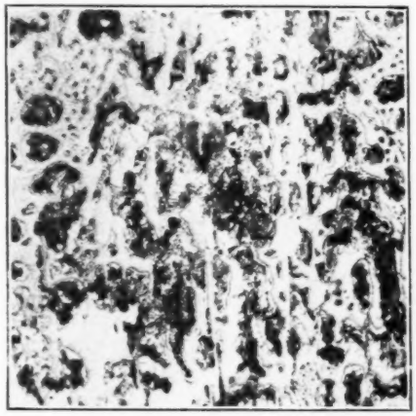


Fig. 3.—Chill Etched × 100.

grain showing through the chill, the trained eye of the roll turner detects small spots which the microscope confirms to be half-formed rosettes of graphite formation.

The sulphides shown in the photomicrographs are interesting on account of their characteristic shapes. Whether in grey iron or in the chill portion of a roll, these characteristic crystalline shapes are noticeable. It is hardly likely that a constituent formed in the pasty or solid condition would have regular or characteristic form, especially in a material so quickly solidifying as chilled iron. Moreover, these shapes are the same and of similar size even in the grey iron which is much more slowly cooled.

Hence the conclusion is indicated that since the metal is cooled to 1,250 deg. or less before casting, the sulphide crystals were already formed in the liquid iron and in a state of suspension.

Since the sulphur enters the iron by chemical combination and the sulphides do not take opportunities of separating out, it would appear that at some higher temperature the manganese sulphide is in solution, and the crystals separate out as the liquid cools down to 1,250 deg.

The presence of these sulphides, according to the amount of sulphur present, clearly indicates that, provided there is sufficient manganese present to combine with the sulphur, the latter is rendered comparatively innocuous, since the product is in the form of inclusions, of which cast iron contains so many in much larger amount, viz:—graphite flakes. The prints, Figs. 3 to 8, are all from one roll, and may be considered typical.

Fig. 3 is not pure chill, since a partly formed rosette of graphite may be seen in the centre. Fig. 4 shows the graphite arrangement of the grain portion, together with manganese sulphide. Figs. 5 and 7 show the same cluster of sulphide. Fig. 8, representing the zone of mottle, shows pearlite, cementite, characteristic sulphide crystals and graphite. Figs. 9 and 6 are photographed from two further rolls, the rather numerous sulphide crystals in Fig. 9 following the analysis, 0.18 per cent. sulphur.

Fig. 11 illustrates the fractures of chill test-pieces. The first and second are successive spoon tests taken from the oil furnace at an interval of 12 mins., and read 1 $\frac{15}{16}$-in. and 2-in. chill respectively. The third is the final test-piece of the same cast, after a small addition of grey iron, and shows 1 $\frac{15}{16}$-in. chill. The analysis of the roll was C., 2.58; Si, 0.96; Mn, 0.30; S., 0.10; and P., 0.41 per cent.

The fourth piece reads 1 $\frac{1}{2}$-in. chill, of typical analysis, C., 3.10; Si, 0.75; Mn, 0.35; S., 0.10; and P., 0.40 per cent., and the fifth, added for interest, represents a test-piece from a low-silicon cast iron with 7/16-in. chill.

Consideration of Results.

The analyses given in Table IV are taken from rolls of satisfactory service by various makers, and over a period of years, and the chill-depth would range from $\frac{7}{8}$ in. to 1$\frac{1}{4}$ in. in the rough before machining.

The actual depth of chill after machining would depend upon the depth of metal to be removed to obtain a sound surface, but normally $\frac{3}{16}$ in. to $\frac{1}{4}$ in. is cut away. From studying the fractures of many broken rolls, a point well known to roll turners was demonstrated, that the real chill in the centre of the barrel is frequently deeper than the chill indicated at the ends. Occasionally less chill is found in the centre. This leads to the suggestion that the chill-mould should be arranged to cast the barrel, say, $\frac{3}{4}$ in. longer than required, leaving a good machining allowance at the ends of the barrel, so that the chill-depth may be more reliably indicated by the turned end.

Satisfactory Service Defined.

The analyses recorded seem to indicate that sulphur and phosphorus within limits do not greatly affect the serviceability of the rolls. Satisfactory service may be taken as representing the rolling of 600 to 700 tons of steel strip over a period of six months, and including 45 to 55 dressings by turning or grinding. Having due regard to the possibility that each of the rolls mentioned above is the sole survivor of a large number of the same

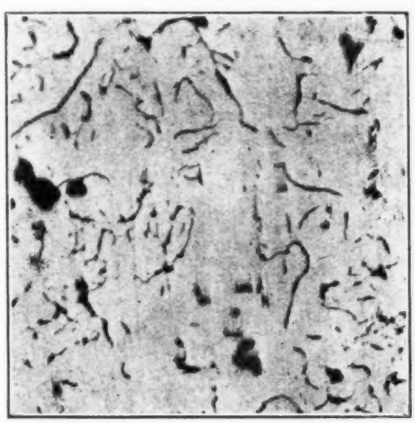


Fig. 4.—Grain Unetched × 100.

type, and has not succumbed to the numerous casualties of service, it may be said that of some hundreds of rolls recorded the above figures are quite typical of satisfactory service.

Of each cast of rolls made in the present experiments, the analysis, casting temperature and life in service were recorded. A stamped tally was fixed in the top of each roll head before final solidification, and the number transferred to the roll by the turner, every dressing operation being booked up against its number. If, on account of blemishes it was necessary to reduce the diameter, and with that the working life, that also was noted. No roll was put into service if it was judged unlikely to earn the cost of turning and grinding, through lack of chill-depth or deep-seated blemishes, the removal of which entailed excessive reduction of the diameter.

Factors Governing Success.

The factors governing the success or failure of each roll were found to be mainly the depth and nature of the chill. The latter refers to the mildness or harshness, which are decided by the carbon contents. It has been pointed out elsewhere that chilled iron having carbon contents of 3.3 per cent. by structural composition corresponds to 50 per cent. pearlite and 46.5 per cent. cementite, and from the analysis of satisfactory rolls it is clear that 50 per cent. pearlite is a minimum figure and 46.5 per cent. cementite a maximum figure for the chill of good rolls. These

Fig. 5.—Chill Unetched × 300.

limits were not found possible of attainment with metal produced in the cupola.

It is quite true that rolls made from five casts gave excellent service, and many were used for a satisfactory period, but all were liable to develop cracking after a few shifts' use and finished their work in the roughing housings. With the addition of oil-furnace metal, and consequent lower total carbon produced, there was a marked improvement in the life of the rolls. The first noticeable feature with lower carbon rolls was the necessity of having more chill on the test-piece before casting, since the difference between test-pieces and rolls is much more pronounced.

Thus with the cupola-cast rolls, in order to produce 1-in. chill on the finished roll, the test-piece should have 1$\frac{3}{8}$ in., allowing $\frac{3}{16}$ to $\frac{1}{4}$ in. for machining and $\frac{1}{8}$ in. for slower cooling of the larger mass. It was definitely found that the lower the carbon contents the greater the drop between test-piece and roll. Thus a roll of the following composition, C., 3.11; Si, 0.74; Mn, 0.29; and P., 0.59 per cent., cast at 1,250 deg. C., recorded 1 $\frac{7}{16}$-in. chill on the test-piece. After service the roll was cut up for examination, and allowing for turning, the depth of chill in the cast conditions must have been $\frac{7}{8}$-in.

Another roll with C, 3.27; Si, 0.71; Mn, 0.29; S, 0.13; and P, 0.28 per cent., giving 1$\frac{7}{16}$ in. chill on the test-piece, was reported by the roll turner to have $\frac{7}{8}$ in. to 1 in. chill in the rough.

Of the milder rolls to be discussed hereunder, one cast analysing out at C, 2.71; Si, 0.92; Mn, 0.32; S, 0.12; and P, 0.36 per cent., gave 1$\frac{15}{16}$ in. chill on the test-piece. When used until grain showed through the chill, it was measured up and proved to have had only $\frac{7}{8}$ in. chill in the rough. Further, the zone of mottled iron between chill and grain is much deeper. These points appear to be conclusive evidence that the silicon contents regulate the depth of chill by ejecting carbon from solution, in proportion to the amount of each element present. It was considered that possibly rolls of very low carbon would be more serviceable than the usual mild rolls, and accord-

ingly low-carbon, or semi-steel, rolls were made, as indicated in the section on operations.

The first attempt failed, because with the lower carbon, there was insufficient silicon to precipitate graphite, in other words, the roll was almost completely white iron to the centre.

In order to start from a known base, liquid metal was prepared by a joint melt, and the chill adjusted and one roll cast. It was then assumed that the carbon and silicon were known in the remaining metal, which was returned to the oil furnace, into which mild steel, ferro-silicon, and a little ferro-manganese had been charged. Spoon tests were taken when the metal was again hot. Since these, at 5-minute intervals, gave 1 13/16 in.

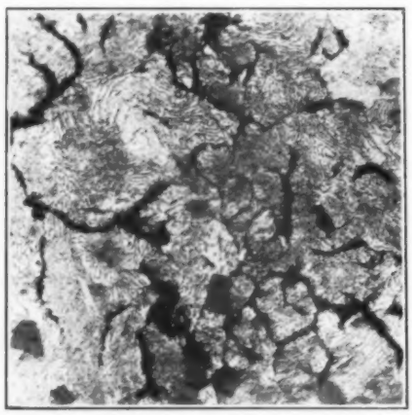


Fig. 6.—Grain Etched × 300.

and 1⅞-in chill, the metal was considered right, and was tapped and cast, the final test-piece showing 2 in. The analysis taken from the runner was C, 2.50; Si, 1.11; Mn, 0.35; S, 0.15; and P, 0.39 per cent.

These rolls rendered conspicuously good service, and after 36 dressings were still uncracked and serviceable. The experiments were repeated and good rolls produced, of which several promising pairs had only a short life, from stickers and other casualties. In other cases it was found extremely difficult to obtain correct chill depth on the test-piece, without grain showing through on the machined surface of the rolls.

Standardising Chill.

Attempts have been made to draw up some rule as to the relative effects of carbon and silicon by arranging analyses in order of carbon contents, and thus to standardise the chill, and also in order of chill depth to standardise analysis.

Table VIII.—*Chill, 1⅜ in. to 1 7/16 in.*

No.	C.	Si.	Mn.	S.	P.
241	2.68	1.05	0.40	0.14	0.50
258	2.74	1.00	0.34	0.09	0.43
244	2.78	0.84	0.38	0.13	0.44
253	3.02	0.85	0.37	0.16	0.54
232	3.02	0.88	0.38	0.17	0.46
219	3.03	0.85	0.36	—	0.44
215	3.16	0.80	0.34	0.16	0.49
218	3.16	0.74	0.30	0.14	0.44
312	3.18	0.83	0.38	0.13	0.46
217	3.18	0.81	0.37	0.15	0.43
212	3.20	0.85	0.39	—	0.29
216	3.28	0.88	0.32	—	0.42

Average: C, 3.04; Si, 0.86; Mn, 0.36.
Average, excluding carbon under 3 per cent.: C, 3.13; Si, 0.83; Mn, 0.36.

No definite constants were arrived at, but it will be seen from the subjoined tables that it is possible on broad lines to indicate chill from analysis. The figures recorded and summarised in Tables VIII, IX, X, and XI, clearly indicate the relations of carbon and silicon to depth of chill. The variables which prevent a more precise indication are temperature of the hand ladle used in casting the test-piece, and doubt as to the actual measurement of the chill itself, the last grey spot being not always decisive as to the general chill.

It is frequently found that if the test-piece be broken twice, each face of one piece may give different results from the other. Obviously one odd rosette of graphite may occur on the fringe

Table IX.—*Chill, 1¼ in. to 1⅜ in.*

No.	C.	Si.	Mn.	S.	P.
313	2.98	0.84	0.39	0.15	0.38
220	3.00	0.78	0.26	—	0.60
303	3.04	0.78	0.41	0.15	0.41
290	2.92	0.92	0.40	—	0.41
305	3.05	0.75	0.39	0.13	0.40
301	3.11	0.84	0.35	0.12	0.39
287	3.13	0.71	0.32	—	0.37
239	3.14	0.86	0.34	—	0.50
310	3.15	0.79	0.35	0.11	0.36
201	3.17	0.71	0.32	0.12	0.18
200	3.07	0.68	0.35	0.12	0.28
202	3.12	0.64	0.31	0.13	0.31
234	3.15	0.71	0.34	0.18	0.44
236	3.15	0.84	0.33	0.18	0.54
299*	3.48	0.53	0.30	0.14	0.20

* Cast from Cupola metal, omitting which, the average is: C, 3.08; Si, 0.77; and Mn, 0.34 per cent.

Table X.—*1¾ in. Chill.*
Total C under 3 per cent.

No.	C.	Si.	Mn.	S.	P.
238	2.87	0.75	0.35	—	0.55
260	2.37	1.10	0.33	—	0.51
272	2.96	0.74	0.40	—	—
245	2.84	0.91	0.29	0.13	0.70
289	2.97	0.87	0.35	0.11	0.39
314	2.92	0.83	0.33	0.08	0.39
Average	2.82	0.87	0.34	—	—

Total C over 3 per cent.

No.	C.	Si.	Mn.	S.	P.
206	3.15	0.79	0.35	—	—
275	3.01	0.73	0.37	0.17	0.43
263	3.11	0.70	0.26	—	0.44
262	3.21	0.68	0.29	0.12	0.31
286	3.17	0.64	0.32	0.13	0.39
277	3.21	0.69	0.40	0.16	0.37
250	3.12	0.77	0.33	0.11	0.42
Average	3.14	0.71	0.33	—	—

of the mottled zone, and nearer or further away. Therefore, by measuring a number of pieces under the same conditions, and averaging analyses, a fairly good basis is obtained by which to read

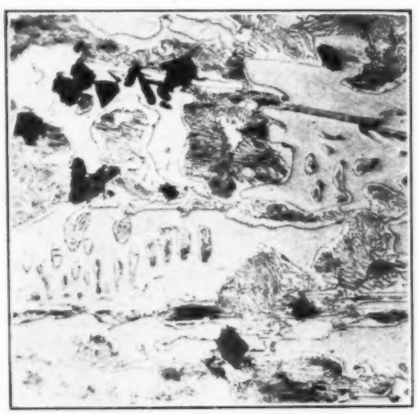


Fig. 7. Chill Etched × 100.

the chill depth from analysis, and, as stated previously, the chill depth on the machined rolls corresponds very regularly to analysis.

From the facts mentioned earlier that the chill test on mild rolls requires longer cooling to be an accurate indicator, and also that there is a larger difference between the chill on the test-piece and that shown by the roll, the opinion was formed that the precipitation of graphite is a much more gradual process than the carbon-iron diagram would indicate. This view was supported by the grain showing through the chill in some rolls, in the form of very small dots, especially when the chill was at all eccentric.

In Table V it was thought advisable, for comparative purposes, to divide the chill tests into two groups, under and over 3 per cent. total carbon. The average figures, while only roughly exact, do clearly indicate that for equal chill, with higher carbon, lower silicon is necessary, and with lower carbon, higher silicon is required to limit the chill by precipitating graphite.

In considering the carbon, there is one point which has a bearing on variable-chill figures. All

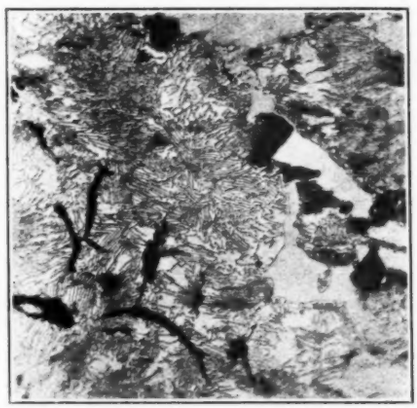


Fig. 8.—Intermediate Etched × 300.

analyses were made on drillings taken from the vertical runners, but these were frequently checked upon chill turnings from the barrel. The carbon was almost invariably higher in the barrel, probably from solution of the graphite facing to the chill mould, thus:—

Carbon, per cent.

No.	Runner.	Barrel.
249	3.11	3.17
237	2.69	2.79*
260	2.37	2.53
279	2.73	2.79
296	3.00	3.08
231	2.63	2.76

* A sample from a cut ⅛ in. deeper gave 2.74 per cent.

Outstanding Service Records.

Two conspicuous features stand out in the records of service; firstly, that the lower carbon rolls were much more durable, having a longer

Table XI.—*Chill Tests on Rolls*

Average of—Casts	Chill.	C.	Si.	Mn.	
12	1⅜—1 7/16	3.04	0.86	0.36	Including C under 3 per cent.
		3.13	0.83	0.36	Excluding C under 3 per cent.
12	1 7/16—1½	3.11	0.81	0.34	One cast C under 3 per cent.
		3.16	0.79	0.35	C over 3 per cent.
14	1½—1 5/8	3.08	0.77	0.34	
11	1 9/16—⅝	3.10	0.74	0.36	
11	1 11/16—1¾	3.03	0.81	0.34	
7	1¾	3.14	0.71	0.33	All over C 3 per cent.
6	1¾	2.82	0.87	0.34	All under C 3 per cent.

period before cracking, and secondly, that the best total service was obtained from rolls without excessive chill. That is to say, that rolls with a maximum of 1½ in. chill on the test-piece, and

a maximum of ⅞ in. chill in the machined condition did best service. Exceptions were found in the case of two casts which cracked after a short life, and the only feature to which failure could be attributed was a somewhat high manganese content of 0.40 per cent.

Other observers have quoted analyses of chilled rolls containing manganese up to 0.5 per cent., but the necessary experiments to prove this point for severe conditions of service would be rather expensive if unsuccessful, so that in these experiments the manganese percentage aimed at was sufficient to neutralise the sulphur and a little more.

It was found that, as stated by others, manganese has the effect of reducing the depth of chill, so that in reading the analysis of a roll to define the chill-depth, the excess manganese over that required to neutralise the sulphur, must be taken into consideration in balancing the effects of the respective carbon and silicon contents.

In view of the known affinity of manganese for carbon, it is somewhat difficult to propound a hypothesis why manganese up to approximately 0.8 per cent. should reduce chill, that is, cause precipitation of graphite. The manganese left over from balancing the sulphur, probably dilutes the pearlite, thus reducing the ratio of cementite

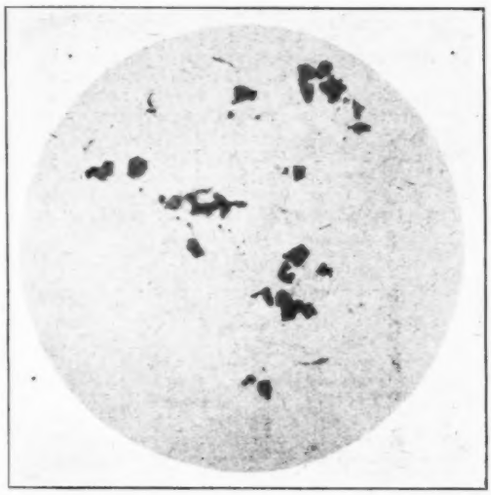


Fig. 9.—Chill Unetched × 300.

to pearlite, and from the manganiferous martensite the silicon is more effective in promoting the precipitations of graphite. With higher percentages of manganese, however, manganese carbide is formed, which is not liable to decomposition by silicon.

Properties of Low-Carbon Rolls.

The properties of the low-carbon rolls are quite distinctive. In casting there is much greater liability to warping and ovalisation, and also to eccentricity of chill. Several promising rolls were rejected, either in turning or after a short life, on account of grain showing through the chill because of eccentricity. This appears to be produced by a symmetrical contraction causing the roll casting to lose contact with the mould, and thereby lose chilling effect, which again points to the duration of the chilling period being longer than is frequently supposed, or at all events to the greying action of silicon being more sluggish in low-carbon metal.

The occurrence of grain in minute spots is serious, because such spots are softer and may lead to stickers. Further, scale is apt to impress the roll, leaving blemishes on the steel rolled. The mild rolls do not take quite such a high polish as the harder rolls, but in service have a much greater resistance to cracking, which more than compensates for the dullness of the surface.

The roll turner points out that rolls of deep chill are harder than those with shallow chill, and that the larger the roll, the milder the chill. Deep chill, following lower silicon, means higher freezing point, with consequently more severe quenching effect and finer grain of pearlite.

Mass action in the case of larger rolls will produce an annealing effect, enabling the pearlite to be of coarser structure. While the very mild rolls are less sensitive to temperature changes, and are

Fig. 10.—Intermediate Etched × 500.

mechanically stronger, there are practical reasons why it is inadvisable to have a carbon content lower than 2.8 per cent. The first is the extreme difficulty of producing the exact depth of chill required, which means a higher percentage of rejections. The second is the liability to impression of the surface by scale and accidental bumps. Thirdly, a better wearing surface is given by the harder rolls, and this is desirable for certain classes of work.

It is, therefore, necessary to strike an average between the various factors. Thus, for this flat work like strip steel, which requires great mechanical pressure on a rapidly cooling material, mildness is desirable. For sections, where the material keeps hotter, and there is a "cushioning" effect, the rolls are required harder to keep section and finish, and extreme mechanical stress is not applied.

In addition to the necessity of having a depth of chill within the somewhat narrow range of 1½ in. to 1¼ in. on the test-piece, and free from eccentricity, it is also highly desirable that rolls should turn up free from blemish, and that this should be achieved by the removal of ¼ in., or little more, of the casting skin, in proportion to the size of the roll.

Scientific Control Inimical to Prosperity.

It is a fairly frequent occurrence for odd defects in the form of gas cavities to mar an otherwise good surface. It may be possible in a section roll to turn out such blemishes, but in flat rolls much good material is liable to be wasted.

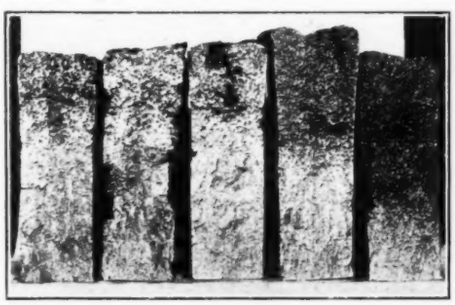


Fig. 11.

After examination of the chill moulds, and in view of the random occurrence of the defects, the conclusion was arrived at that thick spots in the graphite facing are largely responsible. The powdered graphite used was found to contain 17.9 per cent. ash, of which 6.8 per cent. was silicon. Since there is always an apparent coating of graphite left on the mould after casting, it was concluded that impurity of the graphite, excessive thickness of application or filling up of holes, erosion from too violent rotation of the metal, and excessive temperature are the principal causes of blemishes on the chill. In view of the numerous chemical and physical considerations involved, it is clear, therefore, that the production of higher-grade chilled-iron rolls will necessitate the application of scientific control, and it is possible that a higher degree of personal attention to details of manufacture is called for than is requisite in most ferrous operations. In other branches—for example, open-hearth steel—control has passed from the head melter to the chemist in the past quarter-century.

For this difficult branch of iron founding, these experiments seem to indicate that notwithstanding the high skill and long experience of the practical foreman, control must come into the hands of the chemist, who has exact knowledge of the composition of material employed, and their changes in process, and also of the physical conditions necessary to obtain precise results.

American Pig-Iron Output in 1927.

The official figures issued by the American Iron and Steel Institute show a total production of 36,565,645 tons (of 2,240 lbs.) of pig-iron and ferro-alloys compared with 39,372,729 tons in 1926. Of last year's total quantity 19,357,064 tons were basic iron, 9,105,915 tons Bessemer and low-phosphorus iron, 5,504,419 tons foundry iron, 1,699,583 tons malleable pig-iron, 144,532 tons forge or mill iron, 46,719 tons white and mottled iron, direct castings, etc., and 707,413 tons were ferro-alloys.

On December 31, 1927, there were 178 furnaces in blast (as against 205 on June 30, 1927) out of a total of 364. Of those in blast 162 were producing coke iron, 7 charcoal iron and 9 ferro-alloys.

Of the total output of pig-iron 35,693,663 tons were coke-iron, and 164,569 tons charcoal iron; 26,880,343 tons were for the makers' own use and 8,977,889 tons were for sale. The corresponding figures for ferro-alloys were 191,215 tons for own use and 516,198 tons for sale.

Iron and Steel Production in March.

The National Federation of Iron and Steel Manufacturers report that the number of furnaces in blast at the end of March was 150, a net increase of two since the beginning of the month, four furnaces having gone into blast and two ceased operations. Production of pig-iron in March amounted to 592,600 tons, compared with 550,800 tons in February and 671,800 tons in March, 1927. The production in March, 1928, included 194,900 tons of hematite, 202,300 tons of basic, 151,800 tons of foundry, and 24,900 tons of forge iron. Production of steel ingots and castings in March amounted to 793,300 tons, compared with 764,400 tons in February and 949,600 tons in March, 1927.

Paris Foundry High School.

Mr. Ronceray, in his position as director of studies of the Paris Foundry High School, addressed the students last Monday, and took for his text the generation of a true feeling of esprit de corps amongst the students. He insisted that the object of the instruction given was "to light a fire, rather than to fill a jug." The school is now in its fifth year, and already has many successes to its credit.

British Empire Steel Corporation.—Incorporation by Act of Provincial Legislature of Nova Scotia is being sought by the Dominion Steel & Coal Corporation, Limited, to acquire all properties of the British Empire Steel Corporation. The proposed capital, $65,000,000, indicates a drastic reduction of the British Empire Steel Corporation capital, which now stands at $250,000,000.

E

The Properties of C.I. at Low Temperatures.

The influence of low temperatures on the mechanical properties of cast iron has been studied by C. Pardun and E. Vierhaus.* The experiments were made with five different kinds of cast iron the chemical compositions of which are given in Table I. Of each kind 40 round bars of 1.18 in. dia. and five rectangular bars of 1.34 in. × 1.38 in. (length of the bars 31.5 in.) were bottom-cast from one ladle into dry-sand moulds. They were examined for transverse strength, tensile strength, impact strength and the Brinell hardness at various low temperatures. Bars which showed marked defects in the fracture or too high a test-value were rejected. The experimental temperatures, together with the media which were used to produce them, are recorded in Table II. Before being tested, the bars were put into a steel-sheet box containing the freezing mixture and standing in a larger wooden box, the space between the two boxes being filled with slag wool. For attaining the temperatures from ± 0 to − 35 deg. C. the bars remained in the box for two hours; the temperatures of − 80 and − 180 deg. were reached in ten minutes.

Table I.

	Kind of cast iron.	T.C.	Gr.	Si.	Mn.	S.	P.
1	Engineers' cast iron	3.56	3.06	1.80	0.60	0.080	0.527
2	High-duty cast iron	3.42	2.35	1.24	0.56	0.103	0.326
3	Cast-iron pipe	3.64	2.94	1.81	0.56	0.071	0.509
4	Hematite	3.78	3.26	2.03	0.86	0.071	0.095
5	Iron for thin sections	3.42	2.82	2.17	0.49	0.088	1.084

Table II.

Temperature, deg. C.	Freezing mixture.
+22 to +24	Room temperature.
±0	Mixture of ice and water.
−20	100 parts of finely broken ice and 100 parts of NaCl.
−35	70 parts of finely broken ice and 100 parts of crystalline $CaCl_2$ $6H_2O$.
−80	Mixture of solid CO_2 and alcohol.
−180	Liquid air.

Transverse Test.—The bars had a length of 31.5 in. and a dia. of 1.18 in.; the distance between the supports was 23.6 in. During testing the bars were surrounded with the freezing mixture. The test values given in Table III are the average of 8 to 10 experiments. It will be seen that the transverse strength of the irons, Nos. 1 to 4, is not seriously affected up to − 20 deg. C., the differences of a maximum of 4.0 per cent. being normal. From the values of iron No. 5, however, it may be concluded that the brittleness of cast iron high in phosphorus is increased by cold.

Tensile Test.—The test bars were machined out of the fractured transverse test bars. During testing the bars were surrounded by the freezing mixture with the exception of the experiments with liquid air. Here the bars were taken out of the liquid air, wrapped up in cloths and tested, the bars having a temperature of − 100 to − 120 deg. C. during the experiment. From the test-values recorded in Table IV, it is to be seen that the tensile strength slightly increases with the decreasing temperature up to − 20 deg. C. At − 80 and − 180 (about − 100) deg. C. this rise is very remarkable.

Impact Test.—The dimensions of the test samples were 1.18 × 1.18 × 6.3 in.; the distance between the supports was 4.72 in. The time elapsing from taking the samples out of the freezing mixture until they were broken was so short that a rise of the temperature of the cooled samples did not occur. The test-values recorded in Table V show that the diminution of the impact strength is not remarkable, except at − 80 deg. C. and below.

Brinell Test.—The test was taken on the samples surrounded by the freezing mixture. After the rest a photograph of the imprint was made at a magnification of 25 dia.; the area of the photograph was measured, and from this value the diameter of the imprint was calculated. Because of the fact that the imprint at the experimental temperature was smaller than at the measuring temperature (+ 20 deg. C.), the diameter was corrected according to the following formula:—

$$d_{cor} = d - d.\beta.(t_2 - t_1).$$

The test-values (average values of two to three imprints) recorded in Table VI show that the Brinell hardness of cast iron is not greatly increased except at temperatures below − 80 deg. C.

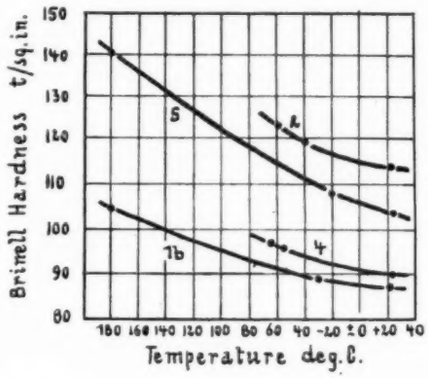


Fig.1.

From the foregoing experiments it can be concluded that low temperatures such as they occur on the European continent do not seriously affect the mechanical properties of cast iron. Fractures which occur very often with castings in the winter season must, therefore, be attributed to the contraction stresses, the serious effects of which can be avoided by a more suitable shape of the casting.

Table III.

Series No.	Temperature deg. C. +23 Transverse strength. t/sq. in.	+23 Deflection. in.	±0 Transverse strength. t/sq. in.	±0 Deflection. in.	−20 Transverse strength. t/sq. in.	−20 Deflection. in.	−35 Transverse strength. t/sq. in.	−35 Deflection. in.	Difference as against + 23 deg. C. per cent. ±0 Transverse strength.	±0 Deflection.	−20 Transverse strength.	−20 Deflection.	−35 Transverse strength.	−35 Deflection.
1	19.18	0.422	20.00	0.433	19.95	0.437	19.31	0.421	+4.1	+2.8	+4.0	+3.7	+0.7	—
2	23.65	0.429	23.10	0.402	24.60	0.425	—	—	−2.1	−6.4	+4.0	−1.0	—	—
3	19.62	0.403	—	—	19.75	0.394	—	—	—	—	+0.65	−2.4	—	—
4	17.28	0.468	—	—	18.04	0.476	—	—	—	—	+4.4	+1.7	—	—
5	21.55	0.396	—	—	19.82	0.341	—	—	—	—	−8.1	−14.0	—	—

Table IV.

Series No.	Tensile strength, t/sq. in. Temperature deg. C. +24	±0	−20	−80	−180 (−100)	Difference as against + 24 deg. C. per cent. Temperature deg. C. −20	−80	−100
1	9.18	9.43	9.75	—	—	+6.2	—	—
2	13.88	—	13.56	—	—	−2.3	—	—
3	9.72	—	10.00	10.80	11.02	+2.9	+11.1	+13.4
4	8.04	—	8.41	—	9.34	+4.5	—	+16.2
5	9.72	—	9.94	10.77	10.99	+2.3	+10.8	+13.1

Table V.

Series No.	Impact strength ft.-lb./sq. in. Temperature deg. C. +23	±0	−20	−35	−80	−180	Difference as against + 23 deg. C. per cent. Temperature deg. C. ±0	−20	−35	−80	−180
1 ..	23.9	23.5	23.8	24.6	—	—	−1.5	−0.6	+3.1	—	—
2 ..	29.1	—	27.3	—	24.3	—	—	−6.2	—	−16.7	—
3a ..	25.7	—	24.1	—	22.5	—	—	−6.4	—	−14.4	—
3b ..	21.5	—	19.7	—	18.4	15.3	—	−8.5	—	−14.3	−28.7
4 ..	27.2	—	25.4	—	23.5	—	—	−6.7	—	−13.4	—
5 ..	22.9	—	22.4	20.3	—	—	—	−2.5	−11.6	—	—

Table VI.

Series No.	Sample No.	Temperature, deg. C.	Brinell hardness. t/sq. in.	Difference as against +20 deg.C. per cent.
1	1a	+ 22	85.1	—
		− 40	93.3	+ 9.7
	1b	+ 22	87.0	—
		− 30	88.9	+ 2.1
		−180	104.8	+20.5
	1c	+ 22	86.3	—
		− 20	88.9	+ 2.9
2	2	+ 23	114.3	—
		− 40	119.4	+ 5.0
		− 60	123.8	+ 8.3
3	3a	+ 23	74.3	—
		− 40	77.5	+ 4.3
	3b	+ 23	97.2	—
		−180	129.5	+33.2
	3c	+ 23	95.9	—
		−180	126.3	+31.8
4	4	+ 24	90.2	—
		− 50	95.9	+ 6.3
		− 65	97.2	+ 7.7
5	5a	+ 24	104.2	—
		− 20	108.6	+ 4.3
	5b	+ 24	102.2	—
		−180	140.3	+37.3

* Die Giesserei, 1928, No. 5, pp. 99-102.

The Mechanical Aspect of Oil Sand Cores.

By Mancunian.

Below are detailed some few points about oil sand cores which have occurred to the author during a few years' experience of their use. Whilst some of them are quite obvious to anyone who has had any dealings with these cores, others may help to elucidate past troubles, and again others might lead to some interesting and useful results if research work could be carried out on the lines suggested. The two more obvious points are: (1) The question of the sand used, and (2) the method of drying.

The sand used must not contain high proportions of silt and clay. The silt and clay particles have a vastly greater area of surface to be covered by the oil than have the particles contained in a similar weight of sand. Consequently much more oil is necessary to get equally strong cores, more gas is given off when the molten iron comes in contact with the core, and as the silt and clay block up the spaces between the sand grains the larger amount of gas has greater difficulty in escaping to the vents. There may be some advantage in using linseed oil in a core sand mixture containing ordinary moulding sand; if so, it has not been found in practice nor is there any theoretical reason for it.

Drying of Oil Sand Cores.

The action is not mainly the driving off of superfluous volatile matter, such as water or mineral oils, though this is necessary with some oil mixtures used. The chief action is the oxidation of the films of liquid linseed or other "drying" oil, which combine with the oxygen of the air to form tenacious films in the same way as does the linseed oil in a film of ordinary paint. Consequently hot *air* is necessary for drying oil sand cores, and a core stove which is filled only with the heated products of combustion of a fire is not very effective.

Action of Liquid Iron on Oil Sand.

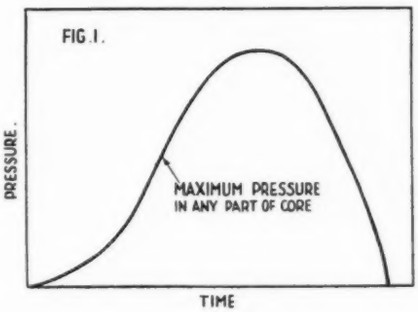
When molten iron is poured into a mould containing a well-vented oil sand core what are the phenomena that occur? Firstly air comes through the vent; this is partly due to the air displaced by the iron from the mould space expanded several times by being heated by the molten metal, and partly due to the expansion of the air contained in the interstices of the core. After a few moments the flow of gas becomes greater; it lights with considerable difficulty to give a non-luminous flame. Rapidly the gas flow becomes greater, and the gas is more easily lighted, while the character of the flame changes to a luminous and smoky one. What has happened is that when the metal has come in contact with the core, the oxidised compound remaining from the oil is partly volatilised, but mainly decomposed, into simpler products, which at the high temperature are gaseous. These create a pressure inside the core, and the gases tend to escape through the vent. The gases are kept inside the core by the pressure exerted on the outside of the core by the head of liquid iron; if the pressure inside the core increases to such an extent while the iron is still liquid that it is larger than the pressure due to the head of liquid iron, then gas escapes through the iron instead of through the vent of the core, and the casting is blown. The heat does not travel instantaneously through the core; if it did a large volume of gas would be evolved at once, and there would be very little hope of it all escaping through the vent. Fortunately the heat penetrates comparatively slowly through the core, and the gases are set free gradually. The gases from the outside layers of the core carry out with them the air remaining in its interstices and give the non-luminous flame which is first obtained at the vent of the core. The heat penetrates further into the core, more and more of the oil film is converted into gas, and the pressure inside the core increases. The critical question is, will this pressure exceed that due to the head of the metal before the metal has solidified? After the metal is solid the pressure matters little; it will hardly rise to such an amount as to burst the solid metal.

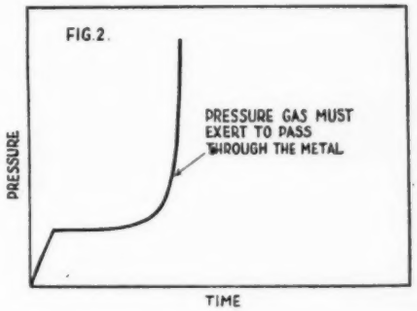
Perhaps the position can be made clearer diagrammatically. If one considers a mould which is being poured and constructs a curve plotting the highest pressure of the gas existing anywhere in the core against the time elapsed, a curve approximately as in Fig. 1 would be obtained. The pressure, which is zero initially, rises rapidly to a maximum and then falls again.

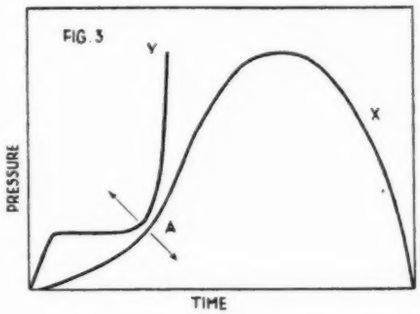
Continuing the consideration of the same mould, one can also construct a curve showing the variation in the pressure which the gas would need to exert if it were to escape anywhere except through the vent (Fig. 2).

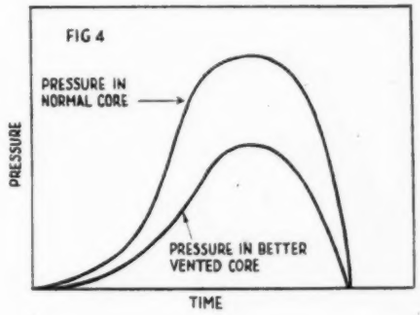
As soon as the core is covered by molten metal, the gas can only escape through the metal if the pressure inside the core is higher than that due to the head of metal at the top of the core. The points on the curve, therefore, correspond to this, rising as the mould is filled and remaining nearly constant while the metal solidifies, with a tendency to rise as the liquid metal becomes more viscous.

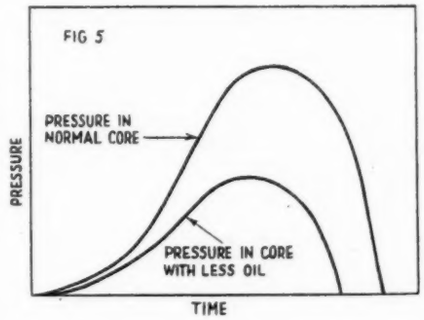
When the metal has solidified the pressure necessary to break open the casting to enable the gases to escape is very large, and the curve rises almost vertically. Now these two curves represent different aspects of the same system, and they can be plotted on the same diagram (Fig. 3). If the curves cut, it indicates that the gas can escape with equal ease through the vent or through the metal, and the casting is certain to be blown. The critical point is A, and the larger the distance between the two curves at this point the less is the chance of the cores blowing; what factors will

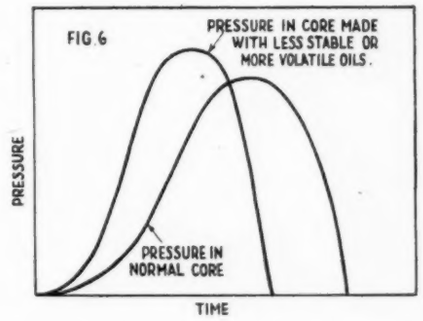


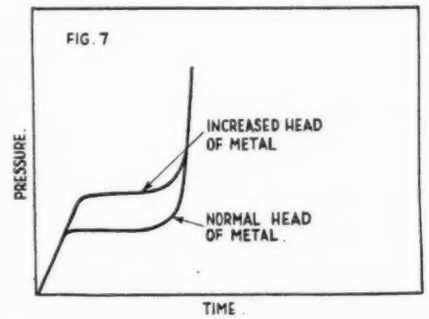


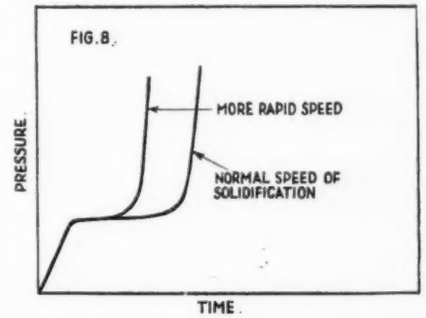












influence this distance? Let us divide them into two classes, firstly those tending to move the danger point on the curve x in the direction shown by the arrow, and secondly those tending to move the point of the curve y in the opposite direction.

Governing Factors.

(*a*) The most obvious factor influencing the curve x is the adequacy of the vent in the core, and this includes not only the vent intentionally formed by the coremaker, but also the spaces between the grains of sand through which the gases can escape to the main vent. The more adequate the venting and the more porous the sand, the lower the pressure which can exist in the core. If every core could be and were made of sufficiently porous sand and sufficiently vented there would be, of course, no blown castings (Fig. 4).

(*b*) If a smaller amount of oil can be used in the core, again the pressure is diminished (Fig. 5).

(*c*) The third point concerns the volatility and stability of the oil used. What is desired is, of course, that the pressure in the core should rise as slowly as possible. If the oil is either very volatile or if it decomposes at a low temperature, the pressure in the core rises very quickly. This partly explains why damp cores are so liable to blow. The water present is almost instantaneously converted into steam, and unless the venting is exceedingly good the pressure in the core rises above the danger point (Fig. 6).

(*d*) The fourth point primarily concerns the design of the castings. For instance, in a core, 1-in. cube, the area of its surface is 6 sq. in., whilst in a second core, identically the same, but a 2-in. cube, the area of its surface is 24 sq. in., and its volume is 8 cub. in. If both cores are completely immersed in molten iron, the gas evolved in a given short space of time is equal to some constant, x, multiplied by the area in contact with the molten iron. With the small core it is $6x$; with the large core, $24x$. But this gas is liberated in one case into the interstices between the sand grains in a core of 1 cub. in., and in the other case into a space eight times as large. In the first case the pressure is raised proportionately to $\frac{6x}{1}$, and in the second to $\frac{24x}{8}$ or $\frac{3x}{1}$. That is to say, the pressure rises twice as fast in the small core as in the large one. With similarly shaped castings it is the small ones which have to be most carefully vented.

Factors Influencing the Position of the Curve "Y."

Increasing the head of metal (Fig. 7).—If when the pouring-basin is filled the surface of the iron is only 2 in. above the top of the core, the pressure of the metal tending to keep the gas in the core is only about ½ lb. per sq. in. If the height is 8 in., the limiting pressure becomes about 2 lbs. per sq. in.

Reducing the time of solidification of the metal, that is the distance between *a* and *b* on Fig. 8. If this time is reduced the distance between the two curves is increased, and with it the probability of a good casting. Various factors influence this, as, for example, the temperature of the metal and its composition; the temperature and material of which the mould is made, and especially the thickness of the casting and the way in which it is run. If a casting is poured through one runner only, the mould near this runner necessarily gets hotter than the remainder; the metal remains liquid at this point longest, and the casting may be blown near to the runner because of this. Small runners and plenty of them certainly give the best results with castings with intricate cores.

The author suggests to core-oil manufacturers that two of the most important factors concerning their mixtures are the total volumes of gases evolved by cores made from their oils, and the speed at which these gases are evolved. It would be no difficult matter to get figures comparative, say, to those of a core of equal strength made from linseed oil alone.

As a foundry manager, the writer is frequently asked to buy various kinds of core oils. The chief selling-argument used is that this is just what so and so uses. Sometimes the offer is made that an exact replica of what he is now using is available. Usually the conversation ends with, "Well, anyhow, I'll leave you this sample, and I shall be very glad if you will try it." The author invariably tests the samples and finds them not as good as his normal supply. It seems to the writer that no very great amount of investigation would be necessary in order to obtain data which would enable core-oil salesmen to place before prospective customers definite facts about their products. Facts such as the following would help a foundry manager in the consideration of a new core oil:—

(1) The relative proportions of the mixture and of ordinary commercial linseed oil necessary to give a core of some definite strength, both cores being dried under those conditions previously established as being most suitable for them. From this figure the relative cost can, of course, be calculated. These cores would be the standard cores for comparison in the following ways.

(2) Particulars of the times and temperatures of drying necessary to give these cores of maximum strength. Quick-drying core oils would very definitely be worth a higher price to a thoughtful founder.

(3) Tests of the strengths of such standard cores after being for different periods in contact with damp sand. Various core oils have been offered to the writer, the cores made from which absorbed moisture freely, and were therefore useless in any foundry where the moulds were not poured immediately they were closed.

(4) The volume of gas evolved from these cores and the rapidity with which it is evolved at some definite fairly high temperature. It is not anticipated that it would be difficult for any chemist with reasonable facilities to get fairly accurate figures for these two properties.

(5) There remains the question of bond in the green core. This property is not necessary for many classes of cores. Where it is desirable in the core sand mixture, it has to be considered in a new core oil, and some test of its amount would naturally be helpful.

These simple tests can, of course, only show the foundryman whether a new oil is worth a trial in the foundry; at any rate, no time would be wasted with the mixtures which some optimists have tried to sell in the past. Only a practical trial on an *extended* scale in the foundry can prove whether the use of a different oil is advantageous.

Handling Castings with Lifting Magnets.

By C. H. S. Tupholme.

A method of handling castings in foundries and machine shops which is coming into greater use is the lifting magnet, usually of the circular type, which can be employed for picking up castings when they are much too hot to handle by any other method. In such a case, the magnet is usually mounted on an overhead telpher running the length of the foundry, the magnet itself being carried on a hook. As soon as the castings are ready to be moved, they are picked up by the magnet, which jars off the sand by tumbling the castings on the floor, and carries them away either to storage or to the next operation without loss of time. In some of the more modern works, this telpher or overhead runway line carrying the magnet is built to run right through from the foundry to the last machine shops, and the castings are carried from the foundry to the first machine shop, from there to the second, and so on, no time being lost through having to handle the castings, which are often exceedingly heavy, by hand.

For this type of service, especially in the foundry, a magnet of exceedingly robust construction is essential, and the circular type is obviously to be preferred to the rectangular magnet. The modern circular magnet is made especially for rough handling, and all parts which are likely to be knocked about are amply reinforced to ensure adequate protection of the magnet itself.

In the choice of such a magnet much depends upon the method of use, as, when the magnet is not being used continually, the lifting capacities are considerably higher than where they are employed all day long. For instance, for light foundry work, an 18-in. magnet gives excellent service. This magnet requires 1.9 amps. on d.c. when working at 220 volts. For heavier work, *e.g.*, in general engineering foundries, the 24-in. size is most useful. This will handle various weights, according to the nature of the material, but 3 cwt. is an average load per lift when the magnet is working all day. The larger sizes will, of course, handle correspondingly heavier loads, the 65-in. red-top magnet lifting a skull-cracker ball of 30,000 lb.

For loading and unloading pigs, scrap and other material, the lifting magnet cannot be

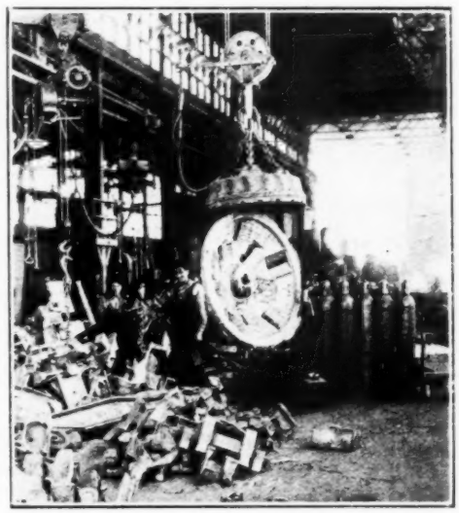


Fig. 1.—An Igranic 36-in. Magnet Handling Electric-Steel Castings (Hot).

excelled for economy and rapidity of operation, while it requires the minimum attention. For such service, the 45-in. magnet will lift 1,000 lb. per trip.

Lifting magnets are designed for operation with direct current, and where alternating current only is available, it can be best transformed to d.c. by a motor generator set or a rotary converter. If steam only is available, an engine or turbo-generator set is the best solution. Gas and oil engines can, of course, also be employed. The standard magnet is wound for 220 volts, though it can also be wound for 110 volts if required. For 500-volt circuits, a 220-volt magnet is used in series with a fixed resistance.

Institute of British Foundrymen.

Lancashire Branch—Junior Section.

The annual general meeting of the Junior Section of the Lancashire Branch was held on April 14 at the Manchester College of Technology. In the unavoidable absence of Mr. T. Makemson, who was away on the Continent, the chair was taken by Mr. R. A. Miles. A *resumé* of the work done during the session was given by Mr. R. Yeoman. He mentioned that the membership was about 60, which was thought to be very satisfactory. The election of officers resulted in the unopposed return of the present holders of offices, and the addition of Mr. Pattison to the Council, the list being:—President, Mr. T. Makemson; Vice-President, Mr. R. A. Miles; Joint Secretaries, Messrs. A. Burgess and R. Yeoman; Council, Messrs. J. E. Garside, J. Pattison, S. B. Poole, W. Walsh, G. Ward, and J. Yates.

Mr. C. F. Brereton read a Paper entitled, "Some Observations on Metallurgical Practice in the U.S.A.," based on what he saw and heard during a visit made by him last September.

Malleable Iron.*

By F. H. Hurren, A.I.C.

Within the last four or five years there has been a very considerable addition to the literature on malleable iron. At the Glasgow Convention of the Institute of British Foundrymen in 1925, the author lamented the fact that the scientific and technical knowledge of malleable iron had not progressed to the extent one might have expected. Research work had been neglected, and the little that had been done by private firms at their own expense remained unpublished. Since then many Papers on the subject have been presented to this Institute, or published in the technical Press, and during this present session Mr. A. J. Beck has read a Paper† on methods of production. It is now rather difficult to bring up any new matter, although there are many points which are still controversial.

At the Glasgow Convention the present author indicated certain lines for possible research, and it has been a source of considerable gratification to me that the British Cast Iron Research Association has taken the matter up wholeheartedly, and has put in hand an organised and systematic research on many of the problems awaiting solution, much on the lines then suggested. Many useful results have been obtained during the last two years and communicated to the members. These alone would well repay membership of the Association, and further work is still in progress.

Previous to this, the only serious researches published are the work of Emeritus Prof. Turner, Dr. Hatfield, and one or two students of Birmingham University, under the guidance of the former.

It is proposed, first of all, to consider briefly the effect of the different elements in whiteheart malleable iron castings used for general engineering work and conforming to the B.E.S.A. standard of 20 tons tensile, with 5 per cent. elongation on 2 inches. If personal views differ from those generally accepted, the author is open to correction.

Silicon.

This element has been looked upon as the governing factor, and to a certain extent founders have been blind to the fact that other elements may have an influence just as profound, and in certain cases working in opposition. It is recognised that a low-silicon content renders malleable iron more difficult to anneal, and a high-silicon content may give a semi-blackheart fracture and poor physical tests, but I do not agree that good physical tests are impossible of attainment with a high silicon iron. Undoubtedly, the best all-round results are obtained when the silicon lies between 0.40 and 0.80 per cent. Below 0.40 per cent. silicon, especially with cupola-melted metal, where the sulphur content is often high, difficulties in annealing may arise. In the Rover Works a silicon content between 0.60 and 0.75 per cent. is sought, due regard being paid to the content of other elements.

The effect of silicon is to assist in the precipitation of free carbon. As the content of silicon rises, the temperature at which free carbon is deposited becomes lower. It has been often noticed that where free carbon is precipitated in the early stages of annealing, this free carbon persists, and the elimination of carbon during annealing is slight. In consequence, there is an excess of carbon in the finished casting, mainly in the free or graphitic form. Unless this carbon is distributed in very small nodules, weakness may result from the presence of flaky graphite. This effect is modified by the percentage of carbon present in the original casting, by the rate of solidification of the hard casting, and by the rate of cooling after annealing.

Carbon.

It is generally acknowledged that the carbon in the hard casting should be almost entirely in the combined form, as the presence of graphitic carbon introduces a risk of flakes of graphite being formed during annealing, with consequent loss of strength in the annealed material. What is not so generally realised is that the carbon content in the hard material may vary within very wide limits. The author has had deliveries of malleable pig-iron with a total carbon content as high as 3.7 per cent., and other supplies with under 3 per cent. carbon. The length of time required for annealing is often considered to be a function of the silicon content, but experience has shown it is determined by the carbon content. It will be realised that the best all-round physical tests are largely dependent upon the carbon content of the annealed material, and the form in which that carbon is distributed. Where a soft, easily-machinable material is required, and very high physical tests are not essential, a short anneal of a high carbon material, followed by slow cooling, will give the desired results. Where high physical tests are required, the elimination of carbon must be considerable, and the composition of the annealed material approximate to that of steel. Any free carbon present must be in a finely divided state and not as flakey graphite.

Elimination of carbon appears to depend to a large extent on time of annealing; the longer the annealing time, the greater the elimination. Experience has shown that the best mechanical results are given by material having a low-carbon content after annealing, with the proportions of free and combined carbon approximately equal. It would appear from this that with a low-carbon pig-iron and a short anneal, results would be obtained equal to a medium-carbon pig with a longer anneal. If such were possible it would be a decided step forward in the cheapening of production of malleable castings. Unfortunately, the problem is complicated by the fact that repeat tests taken under apparently identical conditions of casting and annealing do not show identical physical properties. The question of slight variations of casting temperature, rate of solidification, and rate of cooling after annealing, to say nothing of variations in composition of packing medium, exercises a profound effect on the final result. It has been stated, and to a certain degree proved, that the grain size of the hard material persists after annealing.

Grain Size Persists.

The finer the grain size in the hard casting, the finer the grain size in the annealed casting. The physical test-results increase as the grain size decreases. It naturally follows that a casting in which the metal has set quickly will give better test-results than one which has solidified more slowly. This more rapid solidification occurs in thin sections, and may be effected by casting at a higher temperature, and by the use of chills. An instance of the former effect may be proved by casting two bars from the same shank of metal, one bar being of 1 in. × ¼ in. section, and the other bar 1 in. × ½ in. section. Although they may be annealed together under similar conditions, on the ½-in. bar annealed for a period twice as long as the ¼-in. bar, the latter will give the better physical tests.

Alternatively, the effect of chill may be determined by casting two bars of identical section, one in sand and the other in a chill mould. After annealing together, it will be found that the chill-cast bar invariably gives the better results.

In 1925 the author stated that for the best general results the total carbon in the hard casting should lie between 2.9 and 3.2 per cent. Recent research has tended to prove that statement was correct, and further tests have shown that the least trouble is experienced in obtaining soft ductile material, annealing under ordinary commercial conditions, when the total carbon in the hard casting lies between these limits. Due regard must be paid, of course, to the other constituents.

Sulphur.

The effect of sulphur has been very carefully studied by E. R. Taylor, and published as a Carnegie Scholarship Memoir by the Iron and Steel Institute in 1925. This Paper is well worth studying. Taylor shows conclusively that the ultimate stress and yield point are not appreciably affected until the sulphur content exceeds 0.65 per cent., but both elongation and bend test results fall with increasing sulphur. There is a rapid fall in the elongation up to 0.3 per cent. sulphur. There is also a rapid fall in the bend test up to 0.6 per cent. sulphur, when again the decline becomes gradual.

A sulphur-content of 0.65 per cent. is not often found in commercial malleable castings, and certainly nothing approaching this percentage should be present. In ordinary day-to-day working the maximum sulphur content should not exceed 0.35 per cent. in the annealed casting, and there is something wrong either with the melting practice, the coke, or the pig when this figure is exceeded. In connection with this matter, it is well known that sulphur tends to retard annealing. A combination of low silicon and high sulphur will give a material which is impossible to anneal satisfactorily. The author had a case some years ago, in which the silicon was 0.42 per cent., and the sulphur 0.45 per cent., and the castings were unmachinable after 500 hrs. annealing.

There has been much talk of late on desulphurisation. In works practice there should be no necessity for desulphurising. Pig-iron makers ought to be able to supply material reasonably low in sulphur, and any excessive gain in sulphur during melting, shows cause for an overhaul of the melting practice. However, one should always be ready to try out new ideas, and the author conducted numerous experiments on desulphurising, without any definite advantage accruing. One of the cheapest desulphurising agents is commercial soda ash, and several tests were recently made with this. In the first test, 3½ lbs. of soda ash were added to a ladle of 3½ cwt. metal. A very violent boiling action occurred which lasted five or six minutes. When this subsided and the very fluid slag which formed had been removed, it was found that the metal was too cold to pour, and castings and test pieces were misrun. The sulphur had been reduced from 0.247 per cent. to 0.199 per cent., and there was a very slight loss of silicon. In further tests only half the quantity of soda ash was used, namely 1¾ lbs. to 3½ cwt. metal. Test bars were cast before and after treatment, and all bars annealed together. The loss of sulphur was very small, from 0.295 per cent. before treatment to 0.282 per cent. after. The tensile tests were as set out in Table I.

Table I.—*Influence of Soda Ash Treatment on Tensile Strength of Whiteheart Malleable Iron.*

	Elongation. Per cent. on 2 in.	Ultimate stress. Tons per sq. in.	Yield point. Tons per sq. in.
Before	8.5	22.4	16.05
After	7.0	20.8	15.12

It will be seen that the mechanical properties were not so good after treatment, and as repeat tests gave similar results, the process was discarded.

Malleable Iron.

By F. H. Hurren, A.I.C.

SUMMARY.

In this Paper the author outlines the influence of the various elements on whiteheart malleable iron based on the results of his own personal experiments. A section is devoted to the common troubles encountered, and a new theory is exposed to account for cracking during annealing based on the presence of iron sulphide resulting from low manganese content.

* A Paper read before the East Midlands Branch of the Institute of British Foundrymen, Mr. Pemberton presiding. The author is on the executive staff of the Rover Company of Coventry.

† See page 7 current volume.

Phosphorus.

A very exhaustive research on the influence of phosphorus was carried out some few years ago at Birmingham University, under Prof. Turner's guidance, and it was proved quite definitely that phosphorus in excess of 0.20 per cent. had a very harmful effect on the physical properties. As the ordinary commercial brands of malleable pig rarely contain more than 0.10 per cent. phosphorus, trouble from this source is very unlikely. Some time ago this effect of high-phosphorus content was brought home to the author very forcibly, when by error, a high-phosphorus pig was used in one day's charges. The annealed castings were soft but very brittle, and would break by dropping on a stone floor. The phosphorus content in the casting was 0.40 per cent.

Manganese.

The effect of manganese in whiteheart malleable iron has been studied by E. R. Taylor, and the results embodied in a Paper read at the Sheffield Convention of the Institute of British Foundrymen in 1927. He shows the effect on the physical properties of increasing quantities of manganese, with sulphur remaining constant, and the results are aptly summarised in the statement that "the best results on an ordinary anneal are obtainable when the manganese is approximately 1.7 times the sulphur, whatever this may be." The importance of this statement has been very definitely impressed upon the author recently. The commercial brands of malleable pig contain percentages of manganese varying from 0.05 up to 0.60 per cent., the general run being in the neighbourhood of 0.15 per cent.

The accepted theory of the effect manganese exercises during annealing, is that excess retards annealing owing to the formation of manganese carbide. This is a very stable compound, and may not break down during the annealing process. It is also considered that the manganese combines with sulphur, forming manganese sulphide, which does not retard the precipitation of carbon.

Nickel and Chromium.

Additions of nickel or nickel and chromium are still somewhat in the experimental stage. The chief effect nickel and chromium has on annealed malleable iron is to cause the temper carbon to precipitate in very small spots, which naturally has a toughening effect on the material. Chromium appears to have an action similar to that which it exerts on grey iron, namely, to increase the stability of the combined carbon necessitating an increase in the annealing time.

Influence of Annealing Time.

Practice varies in different foundries, but the average appears to be 30 to 40 hrs. heating up to annealing temperature, maintaining that temperature for approximately 100 hrs., followed by a slow cooling down to black heat, after which the cooling may be more rapid.

The results obtained from personal experiments, examined in conjunction with those of other workers, tend to show that for a definite composition of the hard material, time mainly affects the elongation and angle of bend. A short anneal, that is about 60 hrs., will give a material having certain physical properties, in which the ultimate stress is in the neighbourhood of 25 or 26 tons, with an elongation of 2 or 3 per cent. An increase of annealing time to, say, 100 hrs., only very slightly reduces the ultimate stress, but increases the elongation to 5 or 6 per cent. Annealing for 120 hrs. again has little effect on the ultimate stress, but again increases the elongation. Excessive annealing then seriously reduces the ultimate stress, often accompanied by a reduction in elongation.

From this it may be deduced that for a definite composition of the hard material there is a definite time factor for annealing to obtain the best all-round physical results. It seems feasible, therefore, that the variations obtained in tests on annealed material are due more to irregularity of composition in the hard casting than to variations in annealing time and temperature. If it was possible so to melt iron that all the hard castings approximated very closely to the same composition it is believed that all those castings, when annealed together, would show approximately equal physical results, assuming freedom from casting defects. There must be some tangible reason for the variations now found and the differences between one casting and another, even when annealed under apparently identical conditions. To obtain bulk supplies of molten metal of the same composition is difficult of attainment with the cupola, but should be possible with the air-furnace or the electric furnace, and it is along these lines that better uniformity of result will be attained. The cupola is undoubtedly the cheapest form of melting unit for large tonnages, but if a more regular product is possible with other forms of melting, the gain in that direction may more than counterbalance the increased cost of melting.

Troubles Peculiar to Malleable Castings.

Distortion is a trouble with which everyone connected with the malleable trade is familiar. It may be due to awkwardness of design or to methods of packing. There does not appear to be any royal road to cure this evil, but it can be minimised to a certain extent by care in placing work in the ovens, and by the use of packing strips or blocks cast to the necessary shape and fixed in the hard casting by wedges or clamps.

Another complaint which crops up from time to time is the presence of hard spots or patches where a runner or riser has been ground off. Provided this is not too deep-seated, it has been found that heating up to about 800 deg. C. for three or four hours, followed by slow cooling, generally eradicates the trouble. The local heat generated during "hobbing" may become excessive if there is a large amount of metal to be removed, or heavy pressure is put on the grinding wheel. This has the effect of reversing the annealing process, leaving local areas higher in combined carbon. The subsequent short period of heat, followed by slow cooling, gives a return to the soft state. Provided this treatment is carried out with reasonable care no ill-effects are likely.

One of the most puzzling troubles encountered is the cracking of castings during annealing. Suddenly, and without apparent reason, castings after annealing have been found to have cracks in various places. Some of these occur in the centre of thick sections, often starting from the interior edge and radiating outwards, but not completely through the section. Some cracks appear at the junction of thick and thin sections, others as Y-shaped or star cracks in the middle of a plain section, no part of the crack reaching to an edge of the casting. These latter often have the appearance of cold shuts, and invariably show on the lower surface of the casting as cast. Hard castings have been sand-blasted, examined with a magnifying glass, and tested in other ways to prove entire freedom from cracks, yet after annealing cracks are easily apparent. The troubles have occurred in the Rover Works at irregular periods, sometimes three or four years apart.

Investigating this matter very closely, the author noticed recently that each period of trouble occurred when the manganese content in the iron was lower than usual, and he inclines to the opinion that this is the primary cause of the trouble. It is well known that the manganese should be 1.7 times the sulphur content for the whole of the sulphur to form manganese sulphide. If sulphur is in excess of this ratio, some of it will combine with the iron to form iron sulphide. This tends to form thin threads in the metal, which are lines of weakness, and may develop into cracks on cooling. It has been proved that iron sulphide, or a combination of ferrous sulphide and manganese sulphide, has a lower melting point than manganese sulphide. At the high temperature of annealing this may give rise to local areas of weakness, with a consequent crack developed during the cooling-down period.

In addition, manganese has the effect of retarding the annealing by holding up the precipitation of carbon. In these cracked castings, in addition to a very low manganese content (under 0.10 per cent.), the elimination of carbon has proceeded more rapidly than would have been expected. In many instances, after only 100 hours' annealing, the total carbon has been reduced to 0.60 per cent., and in certain cases even less. Is it not possible that this rapid elimination of carbon, in conjunction with the formation of threads of ferrous sulphide, causes severe internal stresses, and the metal opens out where the threads have formed? This idea is postulated as a possible explanation of the trouble. The experiments are not yet completed, but it is a curious fact that, so far as at present can be said, any tendency for cracks to develop during annealing ceased when the manganese content was raised.

Many of the factors governing the successful production of malleable castings are still obscure, and until these are thoroughly understood, malleable iron will continue under the reproach that it is not an entirely reliable material. This should not be.

It is felt that only collective and concerted action will ensure the greatest good, and this may be best attained by all the malleable-iron manufacturers giving their support to the British Cast Iron Research Association.

DISCUSSION.

Mr. Blades expressed his pleasure with the Paper which had been given; there was no doubt that the author had gone fully into his subject. He would like to have further information regarding desulphurising with respect to hard spots that had been experienced; did not that depend to a large extent on the chemical composition of the metal? Was not the cracking, which occurred during annealing, due to too rapid cooling after the anneal? Could any information be given about the carbon content varying from the skin to the core similar to sulphur, and could any definite particulars be given regarding annealing temperatures?

Mr. S. H. Russell remarked that whilst his knowledge of malleable iron was only very slight, he would like to ask whether in the use of soda ash as a desulphurising agent it was a failure when there was no slag on the metal? Had Mr. Hurren any experience of slag traps or of spouting containing a high percentage of soda ash?

Mr. E. A. Peace was of opinion that the carbon content depended on the method of operating the cupola, and the grain size depended on the silicon content, this being a great factor in the temperature of annealing. He had never had any experience of cracks radiating from various centres, and no one yet had been able to produce manganese sulphide in the presence of iron in theoretical quantities.

Mr. Goodwin pointed out that malleable iron was a very sensitive material, and only those engaged in the industry knew to what extent. He had made a few experiments with nickel and chromium, and found that with the addition of 1 per cent. nickel it made a material difference.

Mr. C. H. J. Beck raised the question of distortion before and after annealing. With respect to the trouble of cracks during annealing, he had had only one experience, which was before the anneal, and was due to an unremoved core.

Mr. Hurren, replying to the discussion, said the difficulty of the hard spots mentioned was not due to chemical composition, by altering which would eliminate the difficulty. It was one of the difficulties that arose in the method that castings had to be run and fed with risers, the difficulty being overcome as he had outlined, due care being exercised. In regard to desulphurising, one could say that soda ash was a qualified success, but when no slag appeared on the metal its action had failed. To the question of the percentage of the sulphur content from the skin to the centre, Prof. Read found sulphur higher in the skin than the centre. The author agreed that the carbon content varied according to the method of operating the cupola; if the cupola was not operating as it should, there was always an increase of the carbon content Bend test of 60 deg. was better for machining than a test of 20 deg. With respect to the difficulty of distortion, his experience was that the percentage before annealing was very low. After annealing, the worst castings with this trouble were plain, flat discs. In regard to annealing temperatures, it was their practice to heat up for 36 hours till a temperature of 960 deg. C. to 970 deg. C. was reached, remaining at this for 96 hours, when it was allowed to cool down slowly 20 deg. per hour to 750 deg. C., after which no ill effects in cooling quickly were experienced.

The Electric Resistance of Cast Iron.

H. Pinsl* has made some interesting investigations on the electric resistance of cast iron of different composition furnished by several works. Samples were examined for the influence of the contents of graphite and silicon of the samples which are arranged according to the increasing silicon content. In Fig. 2 the samples, the silicon contents of which do not differ from each other except by 0.5 per cent., are taken together and the resistance values are plotted according to the increasing graphite content. Fig. 3 shows chemical composition, the structure, the cooling conditions, and the effect of annealing upon the resistance. The test-values, together with the chemical composition of the samples, are given in Table I; the samples are arranged according to their origin and to the increasing content of silicon. Fig. 1 shows the resistance values and the resistance values and that of silicon + graphite.

Table I.

	Sample No.		Chemical composition. Gr.	C.C.	Si.	Mn.	S.	P.	C.	Remarks.
			Per cent.							
A. ..	1	36.7	2.12	0.85	0.62	0.68	0.059	0.18	2.97	Special cast iron.
.. ..	2	59.9	1.80	1.06	1.46	1.11	0.038	0.13	2.86	
.. ..	3	79.1	2.07	0.57	2.33	1.09	0.033	0.22	2.64	
.. ..	4	67.5	1.25	0.90	2.38	1.13	0.070	0.16	2.15	
B. ..	5	66.2	2.39	1.17	1.22	0.28	0.098	0.27	3.56	Special cast iron
.. ..	6	59.3	2.49	0.88	1.33	0.72	0.075	0.17	3.37	,,
.. ..	7	66.2	2.35	1.10	1.37	0.79	0.140	0.22	3.45	,,
.. ..	8	77.2	2.68	0.83	1.50	0.50	0.082	0.36	3.51	,,
.. ..	9	71.6	2.65	0.86	1.56	0.50	0.088	0.44	3.51	,,
C. ..	10	51.5	2.55	0.74	0.80	0.39	0.106	0.43	3.26	
.. ..	11	49.6	0.0	3.19	0.81	0.52	0.102	0.42	3.19	
.. ..	12	50.4	2.14	0.70	0.89	0.82	0.102	0.44	2.84	Special cast iron.
.. ..	13	64.0	2.93	0.77	1.12	0.80	0.059	0.44	3.70	
.. ..	14	65.0	2.86	0.63	1.25	0.44	0.086	0.28	3.49	
.. ..	15	72.5	2.92	0.71	1.31	0.58	0.075	0.56	3.63	
.. ..	16	68.7	2.55	0.73	1.45	0.80	0.143	0.50	3.28	
.. ..	17	76.2	2.85	0.62	1.76	1.00	0.064	0.39	3.47	
.. ..	18	69.9	2.45	0.59	1.80	0.46	0.050	1.27	3.04	
.. ..	19	82.4	2.85	0.59	1.80	0.47	0.043	1.26	3.44	
.. ..	20	79.2	2.38	0.75	1.95	0.98	0.055	0.61	3.13	
.. ..	21	71.3	2.78	0.29	1.97	0.43	0.057	1.46	3.05	
.. ..	22	91.1	2.84	0.59	2.20	0.83	0.081	0.66	3.43	
.. ..	23	81.8	2.90	0.46	2.23	0.53	0.035	1.46	3.36	
.. ..	24	68.1	1.69	1.01	2.28	0.83	0.100	0.32	2.70	
.. ..	25	99.5	3.10	0.45	2.29	0.92	0.074	0.65	3.55	
.. ..	26	66.1	1.69	1.01	2.36	0.83	0.098	0.33	2.70	
.. ..	27	92.3	2.57	0.73	2.36	1.38	0.060	0.67	3.30	
.. ..	28	94.8	3.03	0.37	2.40	0.94	0.050	0.72	3.40	
.. ..	29	101.2	3.10	0.45	2.42	1.06	0.074	0.65	3.55	
.. ..	30	92.3	2.61	0.59	2.52	0.43	0.057	1.40	3.20	
.. ..	31	70.6	1.78	0.74	2.68	0.79	0.104	0.31	2.52	
.. ..	32	148.8	3.41	0.04	2.93	0.44	0.036	1.27	3.45	Pig-iron.
.. ..	33	121.8	3.56	0.42	2.90	0.58	0.057	0.10	3.98	,,
.. ..	34	140.8	3.08	0.20	3.41	0.41	0.024	1.26	3.28	,,
D. ..	35	40.2	2.22	0.90	0.68	0.66	0.134	0.37	3.12	Special cast iron.
E. ..	36	60.8	1.89	0.86	1.94	1.61	0.090	0.16	2.75	,,
.. ..	37	65.4	1.84	0.81	2.01	0.74	0.146	0.12	2.65	,,
F. ..	38	65.4	1.94	0.64	2.12	0.93	0.074	0.20	2.58	,,
G. ..	39	61.2	1.93	0.72	2.01	1.14	0.141	0.26	2.65	,,
H. ..	40	53.4	1.96	0.89	1.27	0.68	0.041	0.21	2.85	,,
J ..	41	47.0	2.82	0.81	0.48	0.49	0.116	0.18	3.63	,,

From Fig. 1 it is to be seen that the resistance curve runs nearly parallel to the graphite curve, and its general direction is that of the silicon curve. This tendency is more pronounced in Fig. 2; the resistance curve of each group shows higher values than that of the preceding group and ascends with the increasing graphite content. The average values of each group of Fig. 2 are recorded in Table II. From these values it can be calculated that 1.0 per cent. of silicon increases the resistance value by 35 micro-ohms when starting from group I to group II, and by about 17 micro-ohms when starting from group II to the other groups.

Table II.

Series No.	Gr.	C.c.	Si.	Mn.	P.	Resistance micro ohms per cub. c.m.
I.	2.37	0.82	0.77	0.63	0.32	45.2
II.	2.49	0.87	1.30	0.67	0.31	63.9
III.	2.47	0.70	1.81	0.75	0.67	72.5
IV.	2.34	0.66	2.29	0.97	0.52	80.6

The higher contents of phosphorus and manganese of the groups III and IV may perhaps influence the resistance value by 2 to 3 micro-ohms, therefore the influence of 1.0 per cent. of silicon is equal to 14 micro-ohms. This value is in close agreement with the experimental results of Partridge,† who found 13.8 micro-ohms. The effect of the graphite cannot be calculated in the same manner, but as is seen from the curves, there is no doubt that the graphite deeply influences the resistance value of cast iron.

Table IV

Sample No.		Resistance: Annealing before—after (Micro ohms. per cub. c.m.)		Resistance: Difference	C. comb. before annealing.
	Cast into sand mould Round bar—				
48	1.575 in. diam.	90.7	88.0	−2.7	0.15
49	1.18 ,, ,,	92.1	87.5	−4.6	0.51
50	0.827 ,, ,,	91.5	86.6	−4.9	0.67
51	0.827 ,, ,,	90.1	83.3	−6.8	0.72
	Cast into chill mould. Round bar—				
52	1.18 in. diam.	85.7	77.0	−9.7	0.60
53	0.827 ,, ,,	74.9	69.3	−5.6	0.40
54	0.512 ,, ,,	69.5	61.6	−7.9	—

The relationship between the resistance and the combined silicon and graphite contents is seen from Fig. 3; the kinks of the resistance curve may perhaps be due to the influences of the other components and the cooling conditions.

As to the phosphorus experiments, other workers

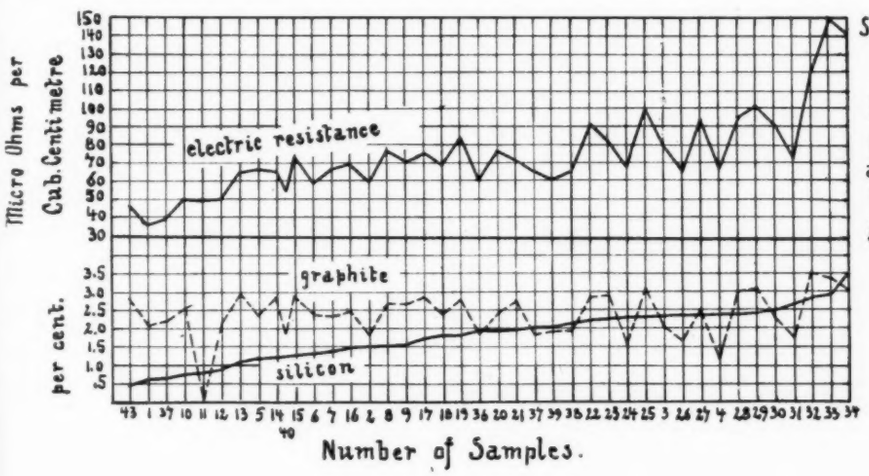


Fig. 1.

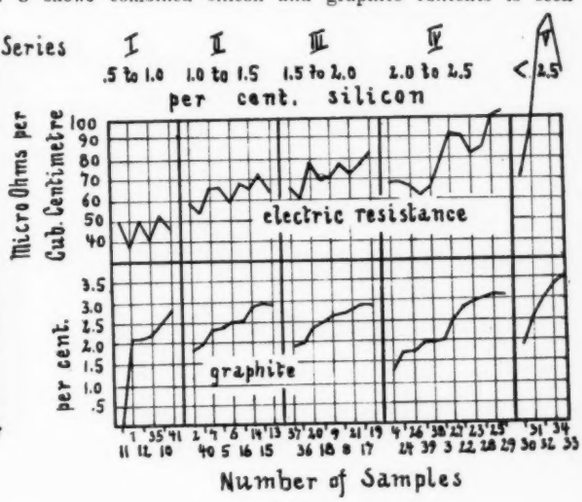


Fig. 2.

* Giesserei-Zeitung, 1928, No. 3, pp. 73/83.

† See FOUNDRY TRADE JOURNAL, issues of June and July, 1926.

have shown that with steel, 1.0 per cent. P increases the electric resistance by about 11.6 micro-ohms. When comparing this figure with the experimental results of the present investigation it can be seen that with cast iron the influence of the phosphorus is greatly diminished. Sample No. 23, for instance, with 1.46 per cent. of phosphorus, shows a resistance value which is about 10 micro-ohms less than that of sample No. 22 containing 0.66 per cent. P, though the percentages of the other constituents are nearly the same. The same is the case when comparing the samples Nos. 18 and 20. This behaviour of the phosphorus in cast iron is explained by the micrographic examination, as is shown later on. The manganese contents of the samples are too low to influence the resistance value to a perceptible degree. The same seems to be the case with the combined carbon, but it is shown later on that the matrix of the samples which is controlled by the combined carbon greatly influences the resistance value.

Influence of Structure.

To show the influence of the microstructure upon the resistance value, there must be examined samples having nearly the same composition, and which show the same distribution of graphite. Sample No. 2, for instance, has a resistance value which is higher by about 24 micro-ohms than that of sample No. 1, though the graphite content is less, and the silicon content is only 0.84 per cent. higher. The micrographic examination revealed the fact that the matrix of sample No. 1 consisted of a well-formed lamellar pearlite, whereas that of sample No. 2 was sorbitic. The same was the case with the samples Nos. 3 and 38. Campbell has found that with steel the combined carbon,

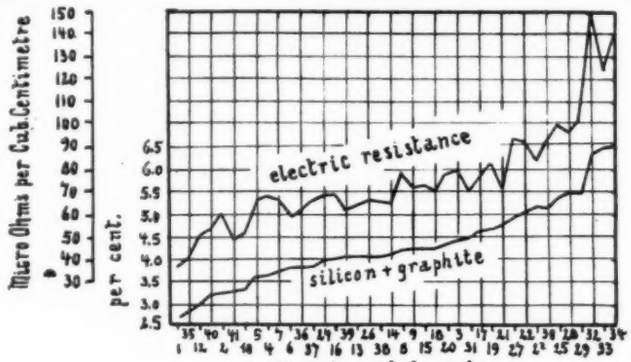


Fig. 3.

Table III.

Series.	Sample No.		C.C. per cent.	Resistance micro ohms. per cubic centimetre.	Structure.
I.		Cast into sand mould			
Composition—	41	Round bar, 1.575 in. diam. ..	Not examined.	108.1	
C. 3.38 per cent.	42	,, ,, 1.18 ,, ,, ..		103.6	
Si. 2.41 ,, ,,	43	,, ,, 0.827 ,, ,, ..		108.0	
Mn. 0.57 ,, ,,	44	,, ,, 0.827 ,, ,, ..		98.2	
S. 0.09 ,, ,,	45	,, ,, 0.827 ,, ,, ..		96.4	
P. 0.93 ,, ,,		Cast into chill mould			
	46	Round bar, 1.18 in. diam. ..		95.5	
	47	,, ,, 0.512 ,, ,, ..		84.0	
II.		Cast into sand mould.			
Composition—	48	Round bar, 1.575 in. diam. ..	0.15	90.7	Very large graphite flakes; matrix for the most part ferritic; some pearlite.
C. 3.30 per cent.	49	,, ,, 1.18 ,, ,, ..	0.51	92.1	Large graphite flakes; matrix: pretty dense pearlite, some ferrite.
Si. 2.01 ,, ,,	50	,, ,, 0.827 ,, ,, ..	0.67	90.1	Finer graphite flakes than in bar No. 49; matrix for the most part sorbitic; no free ferrite.
Mn. 0.35 ,, ,,	51	,, ,, 0.827 ,, ,, ..	0.72	91.5	The same as in bar No. 50.
S. 0.12 ,, ,,		Cast into chill mould.			
P. 0.95 ,, ,,	52	Round bar, 1.18 in. diam. ..	0.60	86.7	Edge: fine graphite nests in sorbite with some ferrite. Interior: fine graphite flakes, lamellar pearlite and sorbite.
	53	,, ,, 0.827 ,, ,, ..	0.40	74.9	Edge: graphite eutectic and ferrite. Interior: fine graphite flakes, pearlite and sorbite.
	54	,, ,, 0.512 ,, ,, ..	—	69.5	Edge: ledeburite. Interior: graphite eutectic.
III.		Cast into sand mould.			
Composition—	55	Round bar, 1.575 in. diam. ..	0.55	96.2	Long graphite flakes, lamellar pearlite and phosphide eutectic, large grains.
C. 3.31 per cent.	56	,, ,, 1.18 ,, ,, ..	0.58	89.8	Graphite flakes somewhat finer and shorter, lamellar pearlite and sorbite.
Si. 1.88 ,, ,,	57	,, ,, 0.827 ,, ,, ..	0.59	87.5	Moderately long graphite flakes in nests, sorbite.
Mn. 0.75 ,, ,,	58	Rectangular bar, 0.382 × 0.217 in.	0.83	81.2	At the ends: ledeburite with some spherolites. Other parts: fine graphite eutectic, sorbite with some ferrite, large phosphide eutectic meshes.
S. 0.128 ,, ,,					
P. 0.61 ,, ,,	59	,, ,, ,, ,,	0.73	76.0	—
		Cast into chill mould.			
	60	Round bar, 1.18 in. diam. ..	0.73	70.6	Graphite nests, in the interior flakes somewhat larger than those at the rim; sorbite, steadite meshes.
	61	,, ,, 1.18 ,, ,, ..	—	73.8	—
	62	,, ,, 1.18 ,, ,, ..	0.48	64.8	Very fine graphite eutectic and sorbite, near the rim some ferrite; no free cementite; steadite around the sorbite-graphite nests.
	63	Gate of chilled bar, 0.492 in. diam.	2.58	78.4	Ledeburite with numerous spherolites of graphite-sorbite in the interior.
IV.		Cast into sand mould.			
Composition—	64	Round bar, 1.655 in. diam. ..	Not examined.	52.4	Large and fine graphite flakes, dense lamellar pearlite, no free cementite.
C. 3.23 per cent.	65	,, ,, 1.655 ,, ,, ..		53.1	—
Si. 0.88 ,, ,,	66	,, ,, 1.30 ,, ,, ..		50.6	Fine graphite flakes, very dense lamellar pearlite, some sorbite, no free cementite.
Mn. 0.95 ,, ,,					
S. 0.08 ,, ,,	67	,, ,, 1.18 ,, ,, ..		56.1	—
P. 0.16 ,, ,,	68	,, ,, 0.788 ,, ,, ..		64.5	Radiated ledeburite, some pearlite-graphite nests (spherolites).
	69	,, ,, 0.788 ,, ,, ..		64.9	—
V.		Cast into sand mould preheated to 180 deg. C.			
Composition—	70	Round bar, 1.615 in. diam.	Not examined.	49.5	Lamellar pearlite, large graphite flakes in the interior, fine ones at the rim.
C. 3.17 per cent.	71	,, ,, 1.575 ,, ,, ..		52.0	—
Si. 0.87 ,, ,,	72	,, ,, 1.14 ,, ,, ..		50.0	Ledeburite with numerous pearlite-graphite spherolites.
Mn. 0.95 ,, ,,	73	,, ,, 1.18 ,, ,, ..		50.5	—
S. 0.085 ,, ,,	74	,, ,, 0.788 ,, ,, ..		55.3	Ledeburite with some pearlite-graphite spherolites.
P. 0.16 ,, ,,	75	,, ,, 0.788 ,, ,, ..		54.5	—
VI.		Cast into sand mould preheated to 395 deg. C.			
Composition—	76	Round bar, 1.575 in. diam. ..	Not examined.	52.5	Moderately large graphite flakes, dense lamellar pearlite.
C. 3.29 per cent.	77	,, ,, 1.14 ,, ,, ..		51.5	—
Si. 0.81 ,, ,,	78	,, ,, 1.14 ,, ,, ..		53.0	Moderately large graphite flakes, dense lamellar pearlite, some sorbite.
Mn. 0.89 ,, ,,	79	,, ,, 0.788 ,, ,, ..		59.7	—
S. 0.081 ,, ,,	80	,, ,, 0.788 ,, ,, ..		59.7	Radiated ledeburite with some pearlite-graphite spherolites.
P. 0.17 ,, ,,					

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especially when exceeding 1.0 per cent., deeply influences the resistance value through the matrix, and that the highest values are obtained with the martensitic structure.

With cast iron the influence of the combined carbon is overshadowed by that of the graphite, and therefore it is not possible to discern it by the chemical analysis. As to the phosphorus, the examination showed that in cast iron the whole amount of this component is present in the form of the binary and ternary eutectic, whereas with steel the phosphorus forms mixed crystals with the iron. The eutectic forms large meshes in the matrix and forces the graphite to segregate in bunches. There is no doubt that the influence of the phosphide eutectic upon the resistance is not so marked as that of the phosphoric iron mixed-crystals, and by the formation of the graphite bunches the resistance is diminished.

In order to examine the influence of the cooling conditions, bars with different diameters were cast into sand moulds, chill moulds, and in the case of a low-silicon content, into preheated sand moulds. From the experimental data recorded in Table III it is to be seen that the resistance of the sand-cast samples containing a high percentage of

Table V.

Sample No.	Resistance. Before annealing.	Resistance. After annealing.	Difference.
	Micro ohms. per cub. c.m.		
1	36.7	38.82	+2.12
2	59.9	59.23	−0.67
3	79.1	81.63	+2.53
4	67.5	64.65	−2.85
5	66.2	59.20	−7.0
6	59.3	54.49	−4.81
7	66.2	59.13	−7.07
8	77.2	72.48	−4.72
9	71.6	67.59	−4.01
35	40.2	40.66	+0.46
36	65.4	62.91	−2.49
37	60.8	61.10	+0.30
38	65.4	65.71	+0.31
39	61.2	55.04	−6.16
40	53.4	47.55	−5.85

phosphorus is diminished with decreasing diameter (series I and III), and that the reverse is the case with the samples containing a low percentage of phosphorus (series IV to VI). The chill-cast samples show a marked decrease of the resistance value. This behaviour of the samples is explained by the micrographic inspection. In series III, for instance, the graphite crystals and the grains of the matrix get smaller when the diameter of the bars is diminished. The graphite is present in the eutectic form, the matrix is pearlitic or sorbitic, and shows small areas of ferrite; the phosphide eutectic forms large meshes.

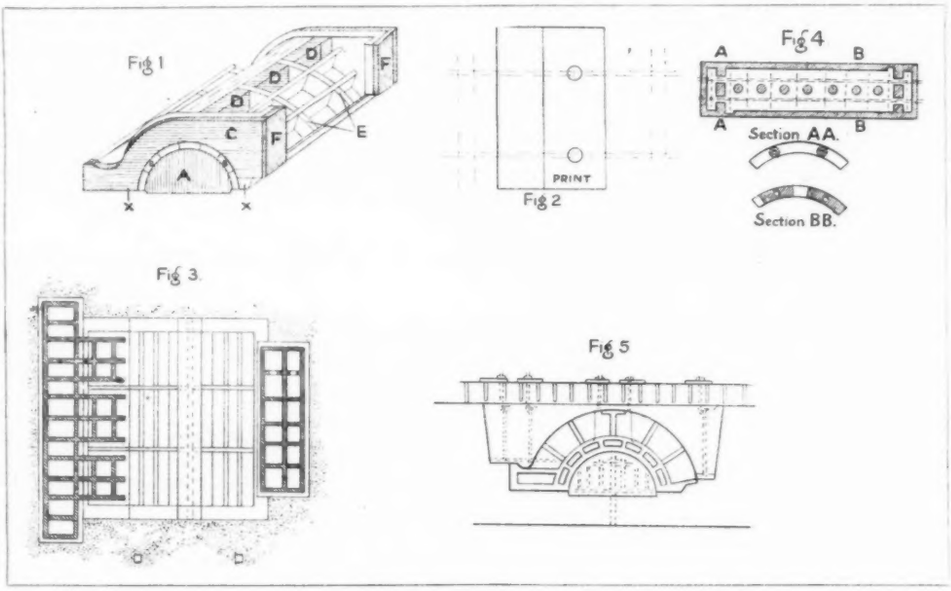
In the samples containing a high percentage of phosphorus no free cementite or ledeburite is present with the exception of sample No. 63. In the series IV to VI the sand-cast samples, with a diameter of 1.18 in., show a large amount of ledeburite, and in the samples of 0.788 in. diameter the ledeburite is the principal constituent. In the series V and VI the preheating temperature of the moulds was not high enough to produce a pearlitic matrix, and here, too, a large amount of ledeburite is to be seen in the texture. In the sand-cast samples of series II the resistance is not diminished with the decreasing diameter. That is due to the fact that a graphite-refining has not taken place, and that the matrix was sorbitic. From the foregoing investigations the following practical conclusion can be made:—In order to get a cast iron with a very low electric resistance, (1) the percentages of silicon, carbon and phosphorus must be kept as low as possible, and (2) the matrix must be lamellar pearlite with fine graphite crystals. The best values are obtained when the silicon content is below 1.0 per cent. and when the carbon content does not exceed 3.0 per cent. In order to get a grey mixture with this composition the cooling rate must be very slow, as in the Lanz process (samples Nos. 1, 12, 35, Table I).

By annealing, the matrix of cast iron is converted to ferrite and temper carbon; the size of the graphite crystals is not altered thereby, as the temper carbon which crystallises around the graphite is in a finely divided state. As the ferrite has a better electric conductivity than pearlite or sorbite, it can be expected that by annealing the resistance will be diminished. The bars of series II, Table III, were heated at 800 deg. C. for one hour, and other bars (Table I) at 850 to 800 deg. C. for two hours. The experimental results recorded in the Tables IV and V confirm the above conclusion. The micrographic examination of the samples 1, 3, 35 and 38 (Table V), which showed a higher resistance value after annealing than before, revealed that the original long lamellæ of the pearlite had been changed to short lamellæ and to the globular form.

Making a Banbury Mixer Side.

By Arthur Greenhalgh.

This job, though not of great size, is heavy, having thick sections of metal. It is one part of a machine for mixing rubber, this type of material necessitating heavy machinery. Fig. 1 is a sketch of the pattern, A being print for body core; B, prints for jacket cores; C, end-cores; D, cores for forming the flange along the top; E represents webs which go round the casting, and F F are also core prints. The size of the job is approximately 4 ft. 6 in. square by 3 ft. in depth.



A hole having been prepared deep enough, two bars are placed across to fasten down the body core, weights being placed at each end to give further resistance. Box parts are placed over that section of the bar, where a clearance is required for the bolt hooks. The bars having been set in position, a layer of sand, 3 or 4 in. deep, is rammed solid. Upon this is placed the cinder bed. A bed is strickled off for the print and the bottom part of the mould, Fig. 2. This having been vented and made solid, the pattern is placed in position and ramming up commenced, ironing well where required. The ingates are located, one on each side of the body core, near the bottom; marked with a X, Fig. 1. Boards having been placed to form a joint for the lift at each side of the pattern, ramming and ironing can go on until the top of the pattern is reached.

During the course of ramming supports for the top part will be placed in position. The joint having been made, grids are placed in position for the two lifts, as Fig. 3.

The six "cods" at the bottom of the lift are carried with irons and gaggers by the joint grid. The three top cods on each side are each carried by a small grid. Each pocket should be well vented and the gases brought away to a central vent in the lift, and eventually through the top part. When the two lifts and cods of sand have been rammed to the top, very little of the pattern can be seen. The cope can now be put on, the grids well "scotched" under the bars, then fastened to the top part by hook-bolts, after which it is rammed up. Good, strong stakes are required, as they must stand 3 ft. above the joint to prevent the top part from being twisted round before it is clear from the bottom. The top part having been turned over, a procedure which requires some care, the broken parts of the mould are made good and then given a good coat of blacking.

Core Making.

The cores D being fastened in position either by the means of wire or small hook bolts after the mould has been dried, very little finishing is required in the bottom half, beyond a little face springing near the runners.

The body core is made with two holes through it from the top to the print side. These holes fulfil two purposes: to allow the bolts to come through for bolting down purposes, and an outlet for the gases in the cores, which go through the bed and so outside the mould. The jacket cores are the most important, and care must be exercised in their making. As will be seen from Fig. 4, a core grid cannot be used on account of the narrow outlets, these being 1¾ in. dia. The grids could, of course, be broken, but the possibility of getting out the broken pieces would be very remote.

The cores were rammed up on two barrels with short pieces of ¾-in. iron tied to them. With the end or filling up cores a grid could be used. In coring up the body core is first placed in position and bolted down, the holes in the core being filled with ashes for air connections, the rest of the hole with sand and then dried. The jacket cores are next located, the core forming a connection at alternate ends so that a continuous flow of steam can go through the casting when in work.

The vents from the jacket cores are all connected and brought away in one place at each end. The end-cores are now placed in position; these cores, besides filling up the print cut away to locate the jacket cores, also hold the jacket cores in position, preventing them from lifting during casting. It is, however, also necessary to place a stud in the centre of the core. The back of the end, or filling-up cores, having been rammed up, the vents from the jacket cores brought away, the bottom part can be considered ready for closing. The small cores can now be fastened in the top part to form the flange. This is best done by small bolt hooks, studs being placed between to prevent them leaning towards the centre. The top part can now be turned over and tried on, before putting on for last time. The risers should be made up to prevent any risk of sand falling in the mould. The top having been placed back, the runner made up, the top weighted, it is then ready for casting. Fig. 5 shows a sectional view of the mould when ready for casting.

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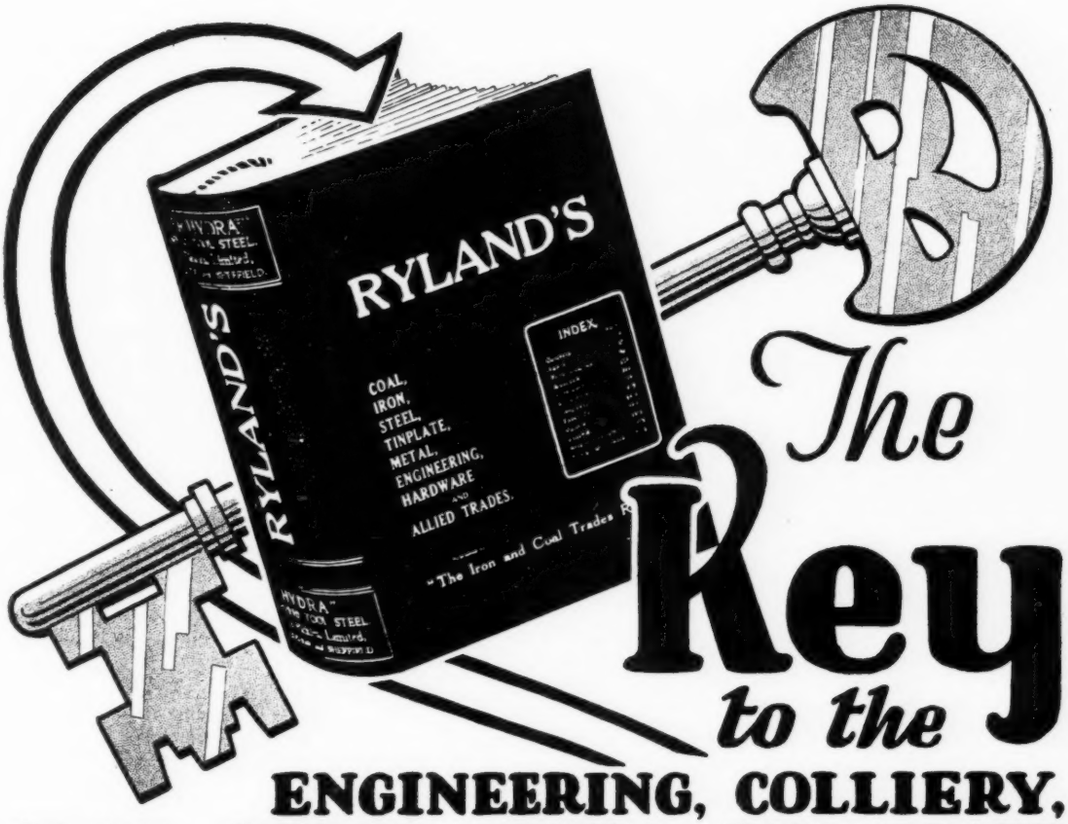

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Trade Talk.

The Enamelled Hollow-ware Committee held a further meeting at 10.30 a.m. on Friday, April 20, in Room 74, first floor, at the Board of Trade, Great George Street, Westminster, S.W.1.

A. E. G. Machinery and Apparatus Company, Limited, 131, Victoria Street, Westminster, S.W.1, announce that the name of the company has been altered to A. E. G. Electric Company, Limited.

The Cleveland Bridge and Engineering Company, Limited, Darlington, have secured a contract for steel work construction of a new bridge across Weymouth Harbour. The bridge is to have a two-leaf rolling lift span, giving a clear waterway of 80 feet. The width of the roadway is to be 26 feet, and altogether 535 tons of steel and cast iron will be used in erection.

Edward Bennis & Company, Limited, have lately taken orders for 22 chain grate stokers for the Sheffield Electric Supply Department, Ashton-under-Lyne Corporation Electricity Works, Yonei Shoten, Tokio, Japan (per Brown, McFarlane & Company, Limited, of Glasgow), Wakefield Electricity Works, City of London Electric Lighting Company, Limited, Bury Corporation Electricity Works, Amalgamated Anthracite Collieries, Limited (Ammanford, Carmarthenshire), and Kingston Electricity Works, Isle-of-Wight (per John Thompson Water Tube Boilers, Limited).

The Wellman Smith Owen Engineering Corporation, Limited, Victoria Station House, Victoria Street, London, S.W.1, have recently received orders for one Wellman electric stripping crane and one Wellman type revolving charging machine for Luxemburg; one Wellman electric revolving five-ton end-grip type ingot discharging machine for plate ingots, and one revolving type open-hearth charging machine for France; also three Wellman gas machines for a large glassworks at Marseilles and one for a glassworks at Givors. There are already 19 Wellman gas machines in the various works of the Souchon-Neuvesel group.

We are informed that the contract for the electric arc welding equipment for the new floating dock destined for Singapore was entrusted to Alloy Welding Processes, Limited. The machine in question consisted of a central motor driving two "A.W.P." patent generators of their now well-known self-stabilising, drooping characteristic type. The motor and generators, together with all necessary control gear, were mounted on a substantial bedplate having small wheels, the whole forming a self-contained portable unit that could be readily moved from one position to another on the floating dock. The machines, of course, had to comply with the special Admiralty rating, and the complete unit has now been delivered to the vessel mentioned.

It is interesting to learn that as a result of their exhibit at the British Industries Fair, Birmingham, Davey, Paxman & Company, Limited, of Colchester, have recently received an order from the Ashford Urban District Council, Kent, for the largest airless injection Diesel engine to be put down in this country for power-station use. It will be capable of developing up to 1,070 B.H.P. Up to now oil engines of this size have always had the fuel oil injected into the cylinder by compressed air on the original Diesel principle. With this engine, however, the fuel oil is injected mechanically on the Blackstone patent "Spring Injection" system introduced a few years ago. Amongst other orders placed as a direct result of the Exhibition is one from the Llandrindod Wells Urban District Council for a smaller engine of 300 B.H.P. The firm reports that the business done at the Exhibition far exceeded their expectations.

The report of the Chemical and Metallurgical Company, Limited, states that very good progress has been made with the erection of the company's works on the Manchester Ship Canal. The plant is being brought into operation in units, and the first unit, an hydrochloric acid plant, was started up on January 1 last, and has worked since without interruption. The second unit will be brought into operation in a few weeks' time. The remaining units will be started in rotation as completed. The first portion of the platinum-copper-nickel plant is nearing completion, and will be brought into operation shortly; construction of the remainder of this plant is proceeding. A pilot plant has been worked at the Stratford Works, treating platinum-copper-nickel concentrates, and results show high recoveries of all metal values at low costs. As previously reported, the directors have made arrangements regarding the funds required to complete the plant as originally designed, and to erect an electrolytic plant for the treatment of the company's zinc residues as soon as a decision is taken on the experts' recommendations to proceed with its erection.

A first and final dividend is to be paid by Mr. S. Buckley, carrying on business under the style of Samuel Buckley & Sons, Admiral Steel Works, Sheffield, of 2s. 9⅞d. in the £.

Messrs. T. C. Futers and R. S. Hughes, electric and oxyacetylene welders, Gorton Street Works, Greengate, Salford, trading under the style of The "Super" Welding Company, have dissolved partnership. Mr. R. S. Hughes will continue the business.

There were launched all over Scotland during February 23 vessels of 18,019 tons—13 of 46,138 tons on the Clyde, six of 1,236 tons on the Forth, one of 360 tons at Dundee, and three of 285 tons at Aberdeen and Moray Firth ports. The shipyards of the Clyde put into the water during the first quarter a tonnage of new vessels larger than that launched in any corresponding quarter of which there are records. They have cleared off the stocks a large proportion of the tonnage which came down as arrears from the mining troubles of 1926, and have given 1928 a start which should ensure it a good normal total at the end of the year—unless there is a pronounced slump later. Their three months' total of 41 vessels of 162,897 tons is more by 15 vessels and 118,765 tons than that of the first three months of last year, it shows a large increase compared with either 1926 or 1925, and it is larger by 13,056 tons than the previous record for the period of 62 vessels of 149,841 tons—in 1921—although the number of vessels launched was smaller.

Arrangements have been effected by which Page-Hersey Tubes, Limited, will take over the plant of the Canadian Baldwin Corporation, Limited, at a price said to be round £100,000. The official statement issued is as follows: The Baldwin Canadian Steel property has been merged with Page-Hersey Tubes, Limited, and its works will be utilised for the manufacture of seamless steel tubing and kindred products. The Page-Hersey Company is the largest manufacturer in Canada of what is known as wrought iron and steel welded pipe, but the demand for seamless pipe is growing rapidly and the merger allows them to enter this field under advantageous conditions, as the Baldwin plant is well suited for the industry and the location particularly good as a manufacturing and distributing centre. The combined enterprise will be in a position to supply a complete line of steel and wrought-iron pipe of all grades, both for domestic and foreign markets, and will consequently effect important savings in manufacturing and sales costs, which, as separate units, they could not enjoy.

Company Meeting.

Thomas W. Ward, Limited.—An extraordinary general meeting was held recently, at Sheffield, to consider resolutions increasing the capital to £1,850,000 by the creation of 375,000 new ordinary shares and 125,000 new second preference shares. Mr. Joseph Ward, J.P. (chairman and managing director), said that the directors had every confidence in asking the shareholders to endorse the resolutions before the meeting. The company was operating thirty-two important works in different parts of the country, all equipped with modern plant and situated in strategical centres. Important waterside properties allowed the company to take advantage, in regard to both import and export, of the large foreign markets which, with the development of recent years, had become open for this country, and were likely to be an important feature in the company's future trading. The company conducted a very large business in coal, coke, pig-iron and foundry supplies, minerals, iron and steel in all parts of the country, and also held sole selling agencies over wide areas with important producing works. In addition to the dismantling of all classes of ships, the dismantling of steel works, mines, factories, etc., formed an important branch of their operations. Since the last increase of capital many important additions to property and plant had been added to the company's assets, amounting to £380,000. Those and other extensions had been financed by bank overdrafts, and when the new capital was received the bank interest saved would increase the profits accordingly. They had taken an interest in the Sheffield Coal Company, Limited, and had decided to take up a controlling interest in a new Portland cement company, and those two investments and the sole agencies connected therewith were expected to add considerably to the profits of the company. For maintaining the efficient organisation and proper equipment of the company's increasing business considerable additions were to be made in connection with their head offices and the Albion Works in Sheffield. Those facilities and the increased capital would better enable them to take advantage of offers of large business which were placed before them from time to time. The resolutions were carried.

Contracts Open.

Galle, Ceylon, May 30.—Cast-iron pipes, for the Galle Municipality:—600 pipes, 12 in. internal diam., 9 ft. in length, wide sockets; 850 pipes, 12 in. internal diam., 12 ft. in length, wide sockets; 3,370 pipes, 12 in. internal diam., 12 ft. in length, turned and bored. The Consulting Engineer, Galle Waterworks, c/o Glenfield & Kennedy, Limited, 39, Victoria Street, Westminster, S.W.

London, E.C.2, May 4.—174 bogie trucks, with wheels and axles and parts for carriage, for the Burma Railways Company, Limited. The Offices, 199, Gresham House, Old Broad Street, London, E.C.2. (Fee £2, non-returnable.)

Johannesburg, June 1.—The South African Railways and Harbours require approximately 2¾ tons of brass piping, ranging in outside diameter from ⅜ in. to 1½ in. and in thickness from 18 to 10 S.W.G.; approximately 6 tons of brass sheets from 26 S.W.G. to ¼ in. in thickness; and approximately 7½ tons of copper sheets, from 26 S.W.G. to 3-16 in. in thickness. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. (Ref. A.X. 6,183.)

Personal.

Mr. Wilfred H. Macdougall has been appointed secretary of David Colville & Sons, Limited, in succession to the late Mr. Norman J. Kerr.

Mr. Thomas Lamont, a partner in the firm of J. P. Morgan & Company, has been elected director of the United States Steel Corporation, to fill the vacancy caused by the death of Judge Elbert Gary.

Mr. A. T. Wall has been elected president of the Liverpool Engineering Society, with Mr. R. F. Baker (Birkenhead), Mr. W. Hinchcliffe, Mr. W. H. McMenemey (Cammell, Laird & Company, Limited, Birkenhead), Mr. B. Rathmell, Prof. G. E. Scholes, and Mr. J. Wilding (Runcorn) as vice-presidents.

Dr. D. S. Anderson, the Principal of the Derby Technical College, has been nominated the chairman of the Derby Society of Engineers. Sir Henry Fowler has been re-elected president, and Mr. C. Carmichael hon. secretary and treasurer. Messrs. W. H. Swift, J. M. Roberts, R. Simpson, G. H. Haslam, W. Price-Abell, S. Moore and G. H. Lake are the committee.

Reports and Dividends.

Brown Bayley's Steel Works, Limited.—Dividend, 6d. per share, free of tax, on preference shares for half-year.

Hopkinsons, Limited.—Final dividend on ordinary shares, 5 per cent., less tax, making 10 per cent. for year; general reserve, £10,000; carry forward, £12,203.

Babcock & Wilcox, Limited.—Net profit, £743,820; dividend on ordinary shares, 15 per cent.; reserve, £100,000; staff pension fund, £20,000; balance carried forward reduced from £161,442 to £125,361.

Howard & Bullough, Limited.—Net profit, £139,145; dividend for the half-year ended March 31 of 6 per cent. per annum on preference shares; fourth quarterly dividend of 2½ per cent. on ordinary shares; carried forward, £66,021.

H. H. Vivian & Company, Limited.—Directors report £5,503 excess profits duty recovered, of which £1,000 reserved for deferred repairs, and £4,503 transferred to profit and loss account; debenture interest, £1,350; depreciation fund, £2,500; surplus, £2,536, reduces adverse balance brought forward to £800.

New Companies.

Anglo-Styrian Steel Company, Limited, Grosvenor Mansions, 82, Victoria Street, Westminster.—Capital £1,000. Directors: P. Ashton, A. J. Egan and P. St. J. Tyrwhitt.

Bolling & Lowe (1928), Limited, 2, Laurence Pountney Hill, E.C.4.—Capital £5,000. Iron and copper dealers, etc. Directors: A. M. Doughty and G. C. Gardner.

C. H. Broughton & Company (Brighouse), Limited, Kirklees Iron Works, Brighouse, Yorks.—Capital £2,000. Ironfounders, etc. Directors: E. Robinson and H. Barraclough (both permanent).

Plenty-Still Oil Engines, Limited.—Capital £47,000 in 46,000 £1 "A" ordinary and 20,000 1s. "B" ordinary shares. Minimum cash subscription, seven shares. Solicitors: Linklaters & Paines, 2, Bond Court, Walbrook, E.C.4.

XUM

"SERVICE GRC FIRST"

ALL YOUR NEEDS IN REFRACTORIES AND MINERALS CAN BE AMPLY FILLED BY

The General Refractories Co. Ltd.

SHEFFIELD.

Enquiries are cordially invited and will be promptly and courteously answered. Expert technical advice on Refractological matters is offered free.

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ETC.

MONOMARK:

BCM / REFRACTORY LONDON.

Telegrams: Refractory, Sheffield *Telephone: 22311 Sheffield.*

Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—The volume of business transacted in the Cleveland iron market continues disappointing in extent, and must still be far below the sanguine expectations of revival anticipated at an earlier period of the year. Expert market opinion apparently attributes the existing slackness to the recent advance of 1s. per ton in current prices, which they contend was a mistake on the part of ironmasters, as confirmed by the fact that some home consumers have found alternative sources of supply, and others, being amply covered for present needs, have simply withdrawn from the market. Of course, in normal times 1s. a ton is neither here nor there, but in these days the market is peculiarly sensitive, and the rise has certainly checked business. The home foundries seem to be fairly well employed, and may possibly be soon compelled to come on to the market for fresh supplies. Meanwhile, prices remain as follow:—No. 1 Cleveland foundry iron, 68s. 6d. per ton; No. 3 Cleveland G.M.B., 66s.; No. 4 foundry iron, 65s.; No. 4 forge iron, 64s. 6d. per ton.

Regarding the position in the East Coast hematite market, business still remains stagnant, demand being limited and stocks heavy. As one merchant put it, hematite is almost as much out of fashion as woollen stockings. Where once the steelmaker relies solely on hematite, he now uses basic iron and scrap. Sellers quote 70s. per ton for East Coast mixed numbers, and 70s. 6d. for No. 1, with concessions obtainable for fairly large tonnages. On the North-West Coast quotations are firmer at 70s. per ton at works for Bessemer mixed numbers.

LANCASHIRE.—In the local markets for foundry pig the most satisfactory feature, perhaps, is the fact that most of the principal makers in the Midlands are able to report a fairly steady flow of delivery specifications against old contracts from consumers in this area. Quotations also are steadily maintained as follow:—For delivery Manchester or equal distance, Derbyshire No. 3 is on offer at between 72s. and 72s. 6d. per ton, Staffordshire brands at round 71s. 6d., Cleveland at about 79s., and Scottish at from 87s. 6d. to 90s.; West Coast hematite iron is quoted at up to 84s. 6d. for delivery to Lancashire users.

THE MIDLANDS.—Conditions in the South Staffordshire markets for foundry material evidence only a slack demand, consumers being still short of orders, which they find very difficult to obtain, and then only at very cut prices. They are not at all anxious buyers of pig-iron, and very few are prepared at this juncture to enter into forward commitments at the prevailing level of prices. The following quotations may be regarded as current quotations:—Northants. No. 3, 58s. to 59s.; Derbyshire No. 3, 63s. 6d. to 64s.; North Staffordshire No. 3, 63s. 6d. to 64s., all per ton at furnaces. Scotch iron is also on offer at 90s., Cleveland, 81s. 9d., and Lincolnshire, 72s. 6d., delivered locally.

SCOTLAND.—The market for Scotch pig remains stagnant, consumers again restricting their buying and adopting a hand-to-mouth policy. The smelters, however, report that, whilst sales are poor, deliveries are going forward fairly well, and in consequence prices are maintained on the basis of 70s. for No. 3 Scotch foundry, f.o.t. furnaces.

Finished Iron.

The reduction in the price of Staffordshire marked bars has not been without its effect upon this class of finished material, and manufacturers are now fairly well employed in this particular branch. There is so far very little improvement to be noticed in connection with "Crown" iron, the prices of which continue to vary to a wide extent. Lancashire grade is offered at upwards from £9, and Staffordshire from £9 5s. to £10. Nut and bolt iron is quoted at £8 17s. 6d. and up. The Continental mills continue to receive the bulk of the business for the latter grade of iron solely on account of the price. The disparity is very marked, as No. 3 foreign iron is offered delivered the Darlaston district at just under £6 5s., a difference of 50s. per ton.

Steel.

A slight improvement in conditions may be noted in the Sheffield steel market, where there is a little more activity, with better buying, not only of acid, but of basic billets. Even so, the demand is much below productive capacity. There is no change in quotations. In wire rods there is severe competition from the Continent. Some mills have been shut down, the orders being transferred to associated mills. Few inquiries are made for open-hearth steel, and high-speed steel is subject to sharp Continental competition. For imported material prices are unchanged, soft Thomas billets, 2 in. and up, being quoted at £5 10s. to £5 11s. 6d. Continental sheet bars and blooms are at £5 10s. and £5 2s. 6d. respectively, delivered works in the Black Country. The tinplate market has not been active, and the volume of business done has not been large. The tone, however, continues to be firm. Several of the works are now well booked for an extended period, and are very firm in their prices.

Scrap.

Demand in the various markets for scrap metals continues slow, with little alterations in quotations for foundry materials in general. On Tees-side the foundries are moderately well employed, and are taking supplies of ordinary heavy cast iron at 62s., whilst sellers are holding out for 66s. as a delivered price for machinery quality. In Scotland prices are reported a shade easier, with heavy machinery cast-iron scrap quoted about 70s., with ordinary quality to the same specification at 5s. per ton less. Light cast-iron scrap is quoted 60s. per ton, and old railway chairs at 70s. per ton, all delivered at works.

Metals.

Copper.—Current values for warrant copper remain at remarkably stable levels, the fluctuations marked in the daily returns being quite unimportant, and indicating an almost entire absence of speculative influence. The immediate outlook is regarded as somewhat uncertain, in view of Continental labour troubles, but an important factor, nevertheless, is that American consumption has experienced a considerable recovery, as indicated by more recent statistics, the returns issued amounting to about 73,000 short tons for March, being about the same as for February, although there was a slight decrease in the takings for export at about 56,000 tons.

Closing quotations are:—

Cash.—Thursday, £61 12s. 6d. to £61 13s. 9d.; Friday, £61 12s. 6d. to £61 13s. 9d.; Monday, £61 10s. to £61 11s. 3d.; Tuesday, £61 13s. 9d. to £61 15s.; Wednesday, £61 12s. 6d. to £61 13s. 9d.

Three Months.—Thursday, £61 13s. 9d. to £61 15s.; Friday, £61 15s. to £61 16s. 3d.; Monday, £61 13s. 9d. to £61 15s.; Tuesday, £61 17s. 6d. to £61 18s. 9d.; Wednesday, £61 16s. 3d. to £61 17s. 6d.

Tin.—Movements in standard cash tin during the past week were influenced chiefly by the issue of the monthly returns, which were not regarded by operators as quite so favourable as expected, and, although America re-entered the market with good quantities towards the close, this had but little effect on sentiment, which has become again exercised to some extent by the steady increase in the output in Malaya. Official returns of F.M.S. exports for March were 5,174 tons, as against 3,988 tons for March last year, and the total for the three months is 14,376 tons, an increase compared with a year ago of 3,090 tons. Home stocks remained at under 2,000 tons.

Official closing prices:—

Cash.—Thursday, £234 7s. 6d. to £234 10s.; Friday, £234 12s. 6d. to £234 15s.; Monday, £232 10s. to £232 15s.; Tuesday, £233 10s. to £233 15s.; Wednesday, £233 10s. to £233 15s.

Three Months.—Thursday, £233 15s. to £233 17s. 6d.; Friday, £234 5s. to £234 7s. 6d.; Monday, £232 10s. to £232 15s.; Tuesday, £233 7s. 6d. to £233 10s.; Wednesday, £233 12s. 6d. to £233 15s.

Spelter.—Values of ordinary spelter have moved up slightly, principally due to fewer offers from the Continent and firmer advices from America on the satisfactory statistics for last month, showing total deliveries at 55,642 short tons, or only 239 tons below the smelters' output.

Official close:—

Ordinary.—Thursday, £25 15s.; Friday, £25 18s. 9d.; Monday, £26 5s.; Tuesday, £26 7s. 6d.; Wednesday, £26 1s. 3d.

Lead.—The market for lead appears to be moving against actual conditions. Both soft foreign prompt and English have shown an upward tendency, but the situation at the same time is uncertain. A few consumers' orders came on the market and helped the recovery, but it cannot be denied that there is plenty of the metal in sight.

Closing prices:—

Soft Foreign (Prompt).—Thursday, £20 8s. 9d.; Friday, £20 13s. 9d.; Monday, £20 16s. 3d.; Tuesday, £20 16s. 3d.; Wednesday, £20 12s. 6d.

Welding Nickel-Chrome Alloys.

By Fred. Grove-Palmer.

When welding chromium-iron alloys in which there is more than 10 per cent. of chromium, there has been found to be little difficulty if the welded vessels are required for ordinary purposes, but when they are to be used for high pressures, where great strength and ductility are needed, the results have not been so good. A great amount of research has been devoted to the solution of the difficulty by the Union Carbide Company, and in the course of this work there have been a number of very interesting discoveries which have added considerably to our knowledge of the behaviour of metals under the action of various influences.

While the welding operations are in progress the chromium contained in the alloy becomes oxidised, and the chromic oxide thus formed is an infusible substance, but unlike the majority of infusible slags it does not float to the surface but remains absorbed in the softened metals. It is quite obvious that unless and until the slag is removed it will form a grave source of weakness in the weld, and therefore the introduction of a flux is indicated as being a prime necessity in order to float off the oxide and to prevent the further oxidation of the metallic contacts.

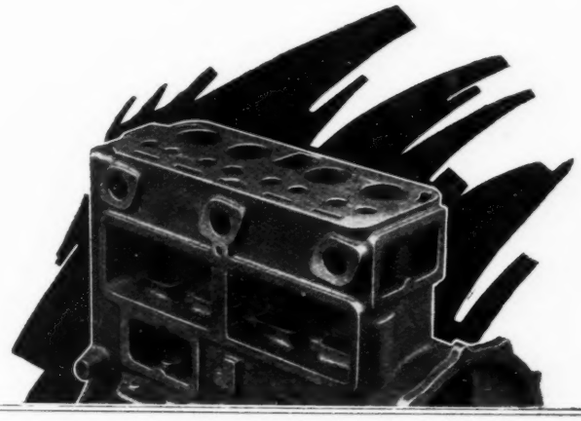
In addition to this fault, which is essentially of a chemical nature, there is also a defect which lies more on the physical side, namely, that of lacking in ductility of both the welded joint and the localised area of the surrounding metal. From the results obtained heat treatment appears to be the best means of overcoming this fault, but only in those cases in which the chromium content is under 20 per cent.

When the percentage is higher than that it would seem that the only effective method of combating this difficulty is to add to the alloy another metal which will change the properties of the mixture in this direction: the metal that has been found to be most useful is nickel, if added to the extent of 8 per cent. A microscopic examination of a prepared surface of this alloy shows that the grain is more refined, while the ductility and power of resistance to shock are both very considerably enhanced. All the former traces of brittleness at the join are found to have been removed, and there is a noticeable improvement in the facility with which the operation of welding may be performed.

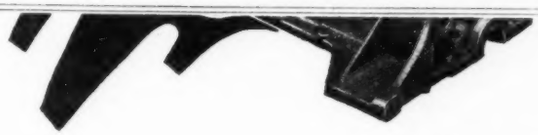
During the further course of the investigation it was found, however, that the addition of nickel to the chromium-iron alloy was not altogether an unmixed blessing, for it was seen that various compounds of sulphur were enabled to act upon the welding surfaces far more readily when nickel is present than when it does not form a part of the metal. This constitutes a very serious defect, and in consequence the inquiry was extended in order that a means might be discovered for overcoming it. This was eventually found by making an addition to the silicon content, bringing it up to about 2 per cent. It was also found to be possible to obtain the same result by increasing the quantity of manganese to the same amount as the silicon; with mixtures of this composition welds were made without the necessity arising for using a flux-covered welding rod.

The publication of these results of the very useful researches has been the means of supplying information to those engaged in the welding industry who have to deal with alloys which contain more than 20 per cent. of chromium, making it possible successfully to overcome the difficulties that arise in getting clear joins and giving, at the same time, a mixture that will weld more readily and possess greater ductility without the trouble of tempering.

WHAT THE BRADLEY SERVICE MEANS TO THE FOUNDRYMAN. No. 2.



18 DIFFERENT GRADES ALWAYS IN STOCK



In every foundry, the occasion arises, at some time or other for a grade of Pig Iron to a definite analysis, to fit in some particular mixture; a Pig Iron to toughen or close the grain, to lower the Silicon or raise the Manganese. However large and varied the stocks of iron on hand, there are times when something different is needed, and it is then that the Bradley Service can be utilised to good purpose.

Bradley's carry considerable stocks of Refined Irons in upwards of 18 different grades. Every cast is carefully analysed and the composition recorded for future reference.

Deliveries from stock can usually be made the same day, and within a reasonable radius delivery by lorry can be guaranteed within 24 hours.

Bradley's

PIG IRON

"A QUALITY FOR EVERY REQUIREMENT"

Write or 'phone for particulars of the Bradley range of Refined Pig Irons. Immediate attention is given to all enquiries and the knowledge and long experience of Bradley's is at the disposal of all foundrymen.

Make full use of The Bradley Service

BRADLEY & FOSTER Lᵀᵈ B&F DARLASTON, STAFFS.

WEEKLY PRICE CURRENT.

COPPER

	£ s. d.
Standard cash	61 13 9
Three months	61 17 6
Electrolytic	66 10 0
Tough	64 0 0
Best selected	64 5 0
Sheets	92 0 0
India	75 0 0
Wire bars	66 15 0
Do. May	66 15 0
Do. June	66 15 0
Ingot bars	66 15 0
H.C. Wire rods	71 10 0
Off. av. cash, March	61 3 6 21/32
Do. 3 mths., March	61 3 9 7/16
Do., Sttlmnt., March	61 3 6 7/32
Do., Electro, March	66 12 2 13/32
Do., B.S., March	65 1 11 1/2
Aver. spot price, copper, Mar.	61 3 7
Do., Wire bars, March	66 15 6 3/4
Solid drawn tubes	13d.
Brazed tubes	13d.
Wire	9 1/2d.

BRASS.

Solid drawn tubes	11 1/2d.
Brazed tubes	13 1/2d.
Rods, drawn	10 1/2d.
Rods, extd. or rlld.	7 1/2d.
Sheets to 10 w.g.	10 1/2d.
Wire	9 1/2d.
Rolled metal	9 1/2d.
Yellow metal rods	7 1/2d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8 1/2d.

TIN.

Standard cash	233 10 0
Three months	233 7 6
English	240 0 0
Bars	242 0 0
Straits	237 15 0
Australian	235 5 0
Eastern	236 5 0
Banca	Nominal
Off. av. cash, March	232 16 5 1/2
Do., 3 mths., March	234 0 1 1/2
Do., Sttlmt., March	232 15 2 1/2
Aver. spot, March	232 16 5

SPELTER.

Ordinary	26 7 6
Remelted	25 5 0
Hard	20 15 0
Electro 99.9	30 5 0
English	26 12 6
India	22 0 0
Zinc dust	33 0 0
Zinc ashes	8 0 0
Off. aver., March	25 0 5 7/16
Aver., spot, March	25 1 7 1/4

LEAD.

Soft foreign ppt.	20 16 3
English	22 0 0
Off. average, March	20 2 10 11/16
Average spot, March	19 18 9

ZINC SHEETS, &c.

Zinc sheets, English	33 10 0
Do. V.M. ex whf.	32 0 0
Rods	39 0 0
Boiler plates	29 10 0
Battery plates	31 5 0

ANTIMONY.

Special brands, Eng.	58 0 0
Chinese	42 10 0
Crude	35 10 0

QUICKSILVER.

Quicksilver	22 5 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	8 1 6
45/50%	12 17 6
75%	20 12 6
Ferro-vanadium—	
35/40%	14/3 lb. va.
Ferro-molybdenum—	
70/75% c. free	4/7 lb.
Ferro-titanium—	
23/25% carbonless	11d.
Ferro-phosphorus, 20/25%	£17 15 0
Ferro-tungsten—	
80/85%, c. fr.	1/3 1/2 lb.
Tungsten metal powder—	
98/99%	1/7 3/4 lb.
Ferro-chrome—	
2/4% car.	£32 17 6
4/6% car.	£22 10 0
6/8% car.	£22 2 6
8/10% car.	£22 0 0
Ferro-chrome—	
Max. 2% car.	£34 17 6
Max. 1% car	£40 0 0
Max. 0.70% car	£46 10 0
70% carbonless	1/2 lb
Nickel—99%, cubes or pellets	£175 0 0
Ferro-cobalt	9/6 lb.
Aluminium 98/99%	£105 0 0
Metallic chromium—	
96/98%	2/9 lb.
Ferro-manganese (net)—	
76/80%, loose	£13 10 0
76/80%, packed	£14 10 0
76/80%, export	£13 10 0
Metallic manganese—	
94/96%, carbonless	1/10 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 3
Finished bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/2 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 1/8 in.	1/- lb.
Flats, 1/4 in. × 1/4 in. to under 1 in. × 1/8 in.	3d. lb.
Do., under 1/4 in. × 1/4 in.	1/-lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£ s. d.		£ s. d.
South Wales—			
Hvy. steel	3 7 6		
Bundled steel and shrngs.	2 16 6	to	3 2 6
Mixed iron and steel	2 17 6	to	3 0 0
Heavy cast iron	3 0 0		
Good machinery for foundries	3 5 0	to	3 7 6
Cleveland—			
Heavy steel	2 17 0		
Steel turnings	2 8 0		
Cast iron borings	2 3 6		
Heavy forge	3 10 0		
Bushelled scrap	3 2 6		
Cast-iron scrap	3 2 0	to	3 6 0
Lancashire—			
Cast-iron scrap	3 5 0		
Hvy. wrought	3 2 6		
Steel turnings	2 2 6		

London—Merchants' buying prices delivered yard.

Copper (clean)	52 0 0
Brass (clean)	38 0 0
Lead (less usual draft)	18 0 0
Tea lead	15 10 0
Zinc	15 10 0
New aluminium cuttings	75 0 0
Braziery copper	47 0 0
Gunmetal	48 0 0
Hollow pewter	165 0 0
Shaped black pewter	125 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	68/6
Foundry No. 3	66/-
Foundry No. 4	65/-
Forge No. 4	64/6
Hematite No. 1	70/6
Hematite M/Nos.	70/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	82/6
,, d/d Birm.	86/-
Midlands—	
Staffs. common*	—
,, No. 4 forge	62/6
,, No. 3 fdry.	64/6
Shrops. basic	—
,, Cold blast, ord.*	155/-
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	—
,, fdry. No. 3	58/6 to 59/-
Derbyshire forge	60/-
,, fdry. No. 3	64/-
,, basic	—
Scotland—	
Foundry No. 1	—
,, No. 3	70/-
Hem. M/Nos.	75/-
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	67/6
Lincs. forge	63/6
,, fdry. No. 3	67/-
E.C. hematite	82/6
W.C. hematite	85/-
Lincs. (at furnaces)—	
Forge No. 4	63/6
Foundry No. 3	67/-
Basic	66/-
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	72/6
Northants foundry No. 3	58/6
Dalzell, No. 3	100/- to 102/6
Summerlee, No. 3	87/6 to 94/-
Glengarnock, No. 3	87/6 to 94/-
Gartsherrie, No. 3	87/6 to 94/-
Monkland, No. 3	87/6 to 94/-
Coltness, No. 3	87/6 to 94/-
Shotts, No. 3	87/6 to 94/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.		£ s. d.
Bars (cr.) nom.	9 0 0	to	10 10 0
Angles			—
Tees to 3 united ins.			—
Nut and bolt iron			8 17 6
Hoops			12 0 0
Marked bars (Staffs.) f.o.t.			12 0 0
Gas strip			11 10 0
Bolts and nuts, 3/4 in. × 4 in.			15 5 0
Steel—			
Ship plates	8 7 6	to	8 12 6
Boiler plts.			10 10 0
Chequer plts.			10 5 0
Angles			7 17 6
Tees			8 17 6
Joists			7 17 6
Rounds and squares, 3 in. to 5 1/2 in.			7 10 0
Rounds under 3 in. to 1/4 in. (Untested)			7 15 0 and upwards
Flats, over 5 in. wide and up			8 17 6
Flats, 5 in. to 1 1/2 in.			7 17 6
Rails, heavy	8 2 6	to	8 10 0
Fishplates			12 10 0
Hoops (Staffs.)			10 10 0
Black sheets, 24g.			9 17 6
Galv. cor. shts., 24g.			13 2 6
Galv. fencing wire 8g. plain			12 10 0
Billets, soft	£6 0 0	to	6 10 0
Billets, hard	£7 2 6	to	7 12 6
Sheet bars	£5 12 6	to	5 15 0
Tin bars	£5 12 6	to	5 15 0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 2 1/2
Sheet to 10 w.g.	1 3
Wire	1 3 1/2
Rods	1 3
Tubes	1 8 1/2
Castings	1 2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3 1/2 to 1/9 1/2
To 15 in. wide	1/3 1/2 to 1/9 1/2
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4 1/2 to 1/10 1/2
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5 1/2
Ingots rolled to spoon size	1/- to 1/8 1/2
Wire round—	
3/0 to 10 G.	1/6 1/2 to 2/1 1/2

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	20.76
No. 2 foundry, Valley	17.25
No. 2 foundry, Birm.	16.00
Basic	18.76
Bessemer	19.26
Malleable	19.01
Grey forge	18.51
Ferro-mang. 80% d/d	100.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	34.00
Wire rods	44.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.85
Tank plates	1.85
Beams, etc.	1.85
Skelp, grooved steel	1.85
Skelp, sheared steel	1.85
Steel hoops	2.20
Sheets, black, No. 24	2.80
Sheets, galv., No. 24	3.65
Sheets, blue an'l'd., 9 and 10	2.10
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.35
Tinplate, 100 lb. box	$5.25

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	—
,, furnace	14/-
Other Districts, foundry	—
,, ,, furnace (basis)	12/- to 13/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14	box	18/3
,,	28×20	,,	36/6
,,	20×10	,,	—
,,	18 3/4×14	,,	—
C.W.	20×14	,,	17/-
,,	28×20	,,	—
,,	20×10	,,	—
,,	18 1/4×14	,,	—
Terneplates	28×20	—	per box basis f.o.b.

SWEDISH IRON.

Bars, hammered, £17 10 0 to £18 10 0	
Rolled Ord.	£15 0 0 to £15 10 0
Nail rods	£15 7 6 to £15 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£8 to £12
Pig-iron	£5 15 0 to all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½%	45%
Water	63½%	40%
Steam	60%	35%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.	
April 19	61	12	6	No change
,, 20	61	12	6	,, ,,
,, 23	61	10	0	dec. 2/6
,, 24	61	13	9	inc. 3/9
,, 25	61	12	6	dec. 1/3

Electrolytic Copper.

	£	s.	d.	
April 19	66	10	0	No change
,, 20	66	10	0	,, ,,
,, 23	66	10	0	,, ,,
,, 24	66	10	0	,, ,,
,, 25	66	10	0	,, ,,

Standard Tin (cash).

	£	s.	d.	
April 19	234	7	6	dec. 7/6
,, 20	234	12	6	inc. 5/-
,, 23	232	10	0	dec. 42/6
,, 24	233	10	0	inc. 20/-
,, 25	233	10	0	No change

Tin (English ingots).

	£	s.	d.	
April 19	240	10	0	dec. 5/-
,, 20	240	12	6	inc. 2/6
,, 23	238	15	0	dec. 37/6
,, 24	239	10	0	inc. 15/-
,, 25	240	0	0	

Zinc Sheets (English).

	£	s.	d.	
April 19	33	10	0	No change
,, 20	33	10	0	,, ,,
,, 23	33	10	0	,, ,,
,, 24	33	10	0	,, ,,
,, 25	33	10	0	,, ,,

Spelter (ordinary).

	£	s.	d.	
April 19	25	15	0	inc. 3/9
,, 20	25	18	9	,, 3/9
,, 23	26	5	0	,, 6/3
,, 24	26	7	6	,, 2/6
,, 25	26	1	3	dec. 6/3

Lead (English).

	£	s.	d.	
April 19	21	15	0	inc. 5/-
,, 20	22	0	0	,, 5/-
,, 23	22	0	0	No change
,, 24	22	0	0	,, ,,
,, 25	22	0	0	,, ,,

Exports of Iron Castings in March and the three months 1928, compared with March and the three months 1927.

	March, 1927.	March, 1928.	Three months, 1927.	Three months, 1928.	March, 1927.	March, 1928.	Three months, 1927.	Three months, 1928.
BUILDERS' CASTINGS—	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Stoves, Grates, etc., Cisterns, Baths, etc., and cooking and washing boilers:—								
To Argentine Republic	144	127	421	435	6,016	4,024	15,117	17,070
,, British South Africa	208	263	702	1,048	6,898	9,424	25,403	35,912
,, ,, India	98	132	314	483	3,552	5,726	14,237	21,889
,, Australia	111	75	291	213	6,408	6,082	16,268	14,636
,, New Zealand	210	165	712	576	9,324	7,327	33,946	27,667
,, Other countries	637	767	2,117	2,342	34,346	34,453	107,453	107,344
Total	1,408	1,529	4,557	5,097	66,544	67,036	212,424	224,518
PIPES AND FITTINGS—CAST—								
To Argentine Republic	821	1,064	2,346	2,191	9,494	9,969	27,276	22,693
,, British South Africa	508	596	1,234	1,280	7,269	8,375	19,951	18,682
,, ,, India	503	1,736	1,155	2,791	7,222	16,239	17,147	32,516
,, Straits Settlements and Malay States	924	646	1,408	3,873	8,726	7,423	15,570	35,491
,, Ceylon	125	49	228	246	1,681	719	3,231	3,405
,, Australia	469	927	932	1,807	6,284	9,705	14,889	20,269
,, Other Countries	4,745	4,531	10,503	15,583	67,031	63,365	160,322	213,434
Total	8,095	9,549	17,806	27,771	107,707	115,795	258,386	346,490
HOLLOW-WARE—								
Cast, not Enamelled, and Cast, Tinned	410	450	1,236	1,158	15,138	16,516	47,112	42,821
,, Enamelled	44	61	174	209	5,451	5,698	17,814	18,511
CASTINGS, in the rough—								
Iron	79	98	381	312	2,928	3,556	13,004	11,636
Steel	130	26	229	121	5,293	1,287	10,983	5,653

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SMALL ADVERTISEMENTS.

Notice.

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED.

ENERGETIC YOUNG MAN, thoroughly conversant with all branches of Foundry work, desires change; experience includes several years in Marine and Jobbing Foundry; present controlling Brass, Iron and Pattern Shops abroad; A.M.I.B.F. and A.M.B.C.I.R.A; highest references.—Box 678, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRYMAN (23), seven years' practical experience of general engineering, jobbing, machine and repetition work, thorough metallurgical training in grey iron, cupola practice, sand control, etc., seeks progressive situation; well educated; first-class references.—Box 692, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

FOREMAN requires position die-casting foundry; 18 years' controlling experience all types of work; automobile and aeroplane work specialist; all alloys, bronze, etc.; design own dies; excellent references.—Box 696, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

METALLURGIST desires post; age 25; degree; 5 years' laboratory, 4 years' foundry and general engineering works experience; thorough knowledge of foundry requirements and modern methods; moderate salary.—Box 694, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

PRACTICAL FOUNDRYMAN, age 34 (leading hand with engineering firm in Yorkshire), desires position as Foreman or Assistant; working not objected to; well trained in all branches of the trade, including cupola practice: Marine, General Engineering or Jobbing preferred; good references.—Box 684, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

BOX 620, The Foundry Trade Journal, 9/2/28. — The various applicants are thanked for their applications, and are informed that the situation is now filled.

THE Government of India require two Inspectors of Stores (Structural) for service in the Indian Stores Department. Candidates must possess a University degree in Engineering, or good general education up to the standard of the Institution of Civil Engineers or of the Institution of Mechanical Engineers, and drawing office experience, and have served a regular apprenticeship in structural engineering workshops. It is essential that they should have specialised in structural steel and bridge work. Age preferably between 24 and 28 years of age.

Agreement for five years in the first instance. The scale of pay applicable to both appointments is Rs. 500, rising by annual increments of Rs. 50 to Rs. 750 a calendar month, with certain allowances. The selected candidates will be granted a commencing rate of pay within this scale commensurate with their age and qualifications. Free first-class passage to India. Provident Fund.

Further particulars and forms of application may be obtained upon request by postcard to the Secretary to the High Commissioner for India, General Department, 42, Grosvenor Gardens, London, S.W.1. Last date for receipt of applications 19th May, 1928.

AGENCY.

LIVE AGENTS required in all districts to handle Core Oils and Creams; good terms offered to suitable men; excellent opportunity for men with Foundry knowledge.—Box 686, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

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PATENTS AND TRADE MARKS.

THE PROPRIETOR of British Patent No. 227,338, dated April 30, 1924, relating to "Improved Process and Apparatus for Disintegrating and Mixing Moulding Sand," is desirous of entering into arrangements by way of a licence or otherwise on reasonable terms for the purpose of exploiting the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. Singer, Steger Building, Chicago, Illinois.

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MACHINERY PLANT, &c., FOR SALE.

PRATT & WHITNEY 14-in. Vertical Surface Grinder.

WILKINSON Automatic Rack-Gear Cutting Machine.

No. 14 "NATCO" Multiple Spindle Drilling Machine.

PARKINSON No. 7A "Sunderland" Gear Generating Machine.

Two dish-ended LANCASHIRE BOILERS, by Thompson; 30 ft. x 8 ft.; reinsure for 150 lbs. per square inch working pressure.

SEVERAL HUNDREDS OF TANKS, rectangular and circular, 10 gallons capacity upwards.

Three-ton LOCO. STEAM CRANE (Grafton); 31 ft. jib; 80 lbs. W.P.; all motions.

Thoroughly reconditioned 2-ft. gauge 40-H.P. "Simplex" PETROL LOCOMOTIVE; almost as new.

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SAND MIXERS.—New and second-hand. Ask us to quote.—W. Brealey & Company, Limited, Prospect Works, Hawksley Avenue, Sheffield.

MISCELLANEOUS.

CHARCOAL.—Powdered, granulated, lump, blacking; inquiries invited.—J. Buchanan & Company, Ashfield Road, Altrincham, Cheshire.

WAX CORE VENTS, yellow and black, all sizes, best carriage paid terms. FLUXES for cleaning brass and aluminium scraps, and for eliminating iron from turnings.—Price list from William Olsen, Limited, Cogan Street, Hull.

MISCELLANEOUS.—*Continued.*

PATTERNS.—Inquiries solicited; quotations by return; shop equipped with modern machinery; quick delivery.—Cleghorn & Company, Midland Pattern Works, Spring Gardens, Worcester. 'Phone 264.

WANTED, Analytical Balance and Weights, load 200 grms; must be sensitive to 1/10th grm. and in good condition.—Write, stating make, type and price, Box 688, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

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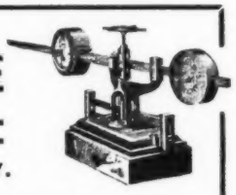

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EVERY SIZE LADLE (1 cwt. to 15 ton) in Stock

LARGEST STOCK OF FOUNDRY PLANT IN ENGLAND. PLEASE SEND FOR LISTS.

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